

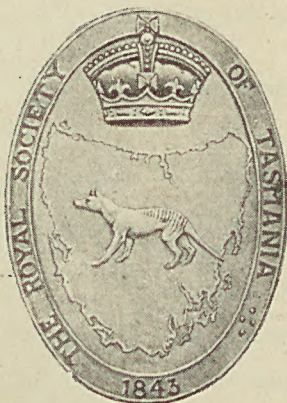
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Some Aspects of the Ecology of the Aboriginal Inhabitants of Tasmania and Southern Australia ⁽¹⁾

By

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(Read 23rd October, 1939)

INTRODUCTION

In choosing my subject for this Lecture, I have been influenced by several considerations and it is fitting that they should be briefly indicated. Clive Lord, in memory of whom this Lecture has been established, was essentially a naturalist in the good old sense of the word and as the lives of the Australian and Tasmanian aborigines were so intimately associated with the natural history of their surroundings, such a subject as their reactions to this environment seemed specially appropriate in a Memorial Lecture to him. Under the conditions laid down, the Lecture must deal with some aspect of Tasmanian history or Tasmanian science. Now I cannot claim any special knowledge of Tasmanian natural history or of the records of the Tasmanian natives, but these natives have again assumed a position of very considerable importance in connexion with the present aboriginal inhabitants of the mainland of Australia. Do these latter, or do they not, show any features which may indicate an admixture of Tasmanian blood?

Amongst recent workers, Dr. Wunderly (1938) maintains that there are characters in the present Australian which indicate a Tasmanian admixture. Messrs. Birdsell and Tindale in a recent expedition, organized by Harvard University and the University of Adelaide, with the aid of a grant from the Carnegie Corporation of New York, have been studying the half-caste Australian and Tasmanian populations. Their study necessarily embraced data from Australian full-bloods as well. Their results have not yet been published, but I have been privileged to read the typescript of their proposed first paper in which they bring evidence to show that there is a very definite Tasmanoid element in the Australian native, in those parts of Australia which may be looked on as peripheral regions. One of such peripheral regions is in the Cairns district and another is along the southern coast of Australia. It is highly probable that their conclusions are correct.

⁽¹⁾ Portion of the Clive Lord Memorial Lecture, 1939.

If it is true that there is an admixture of a Tasmanian type in the Australian native, then the study of the ecology of the latter has a very intimate relationship with Tasmania. In the Southern and Central Australian native we may see traits manifested which are derived from their Tasmanian ancestry, and their methods of procuring a living may be in many points similar to those of the recent Tasmanians as of the forerunners of these who dwelt in Australia.

Having had a number of opportunities for studying the natives of the interior of South Australia and of Central Australia in their natural surroundings, I propose to lay before you some of the results and experiences of these expeditions, having in view more particularly how such can be applied to the native inhabitants of Tasmania.

I cannot resist introducing here the description given by La Billardi re (*vide* Ling Roth, 1890) in 1792 of his meeting with the inhabitants of Van Diemen's Land to compare it with a recent experience in the Musgrave Ranges of South Australia. So similar was the behaviour of the natives in each instance that one is almost tempted to suggest that it was more than a mere coincidence, such as might happen with any group of indigenes, and that it was based on a natural disposition inherited from a common ancestry. La Billardi re had met with a party of natives who then accompanied him for some distance.

'The attentions lavished on us by these savages astonished us. If our path were interrupted by heaps of dry branches, some of them walked before and removed them on either side: they even broke off such as stretched across our way from the trees that had fallen down. We could not walk on the dry grass without slipping every moment; but these good savages, to prevent our falling, took hold of us by the arm and thus supported us. They continued to bestow on us these marks of kindness: nay, they frequently stationed themselves, one on each side, to support us the better.'

A year or so ago, now nearly 150 years after the above incident, Sir Stanton Hicks was engaged in carrying out at Ernabella some physiological observations on Australian natives living under natural conditions in the Musgrave Ranges in the extreme north-west of South Australia. Professor Goldby was with him and, this being the first experience with unsophisticated natives, Sir Stanton was anxious for him to see if possible a corroboree. At dusk one evening, after the day's work, they walked over to the natives' camp and were met by the old men. One of the leaders, anticipating the request they were about to make, asked them if they would like to see one of these ceremonies. Nodding their appreciation of this offer, fire-sticks were quickly got ready and the party moved off in the direction of the ceremonial ground. As the Europeans stumbled along, trying to avoid boulders and fallen branches and the d bris that collects at the foot of these mountains, the younger men, most of whom could not speak English, held their fire-brands so as to light the difficult way as far as possible, turned aside the flexible branches in their path and broke off the dry ones, and even moved stones aside. Then in one place, where the light was particularly dim and a boulder lay in the way, Sir Stanton felt something tugging at his feet and discovered that this was a native lifting his leg off the ground to place it in a crevice of the rock to prevent his slipping!

HUMAN ECOLOGY

Ecology has been defined as 'that branch of biology dealing with living organisms' habits, modes of life and reactions to their surroundings.' We can

go further, however, and say that the ecology, for instance, of the aboriginal inhabitants of Southern Australia and Tasmania, comprises not only all aspects of *their* reaction to their surroundings but also the reactions of their surroundings to *them*.

In studying the ecology of any race of human beings, the following factors will all have to be considered. First, their capacity, mental and physical, to do this and that. Secondly, the nature of the surroundings. In the course of time, a third factor may come in and that is the capacity to meet changes in environment. Man has been singularly successful in his evolutionary ascent for two reasons. First, in his bodily make-up he has never become unduly specialized in any important direction. Secondly, man's brain has so developed that he has in many ways mastered his environment and is now to some extent independent of it.

I do not propose to dwell on the mental and physical capacities of the natives of Tasmania and Australia. The few tools used by the Tasmanians and the primitive nature of these tools indicate that these people were not particularly inventive or ingenious. But then in any European community quite a number of people lack mechanical ingenuity though they may quite readily employ devices invented by others. Moreover such people may possess other mental qualities of a high order. What seems to have been lacking in the Tasmanians who were few in numbers were men of genius outstripping their fellows in inventions which, once discovered, could become common property. One might infer that the Tasmanians did not advance far because the mutations amongst them that produce individuals of superior mental attainments did not unfortunately take the form of mechanical geniuses, at least of mechanical geniuses who could take the occasions presented to them by the hand and lead on to higher things. The Australian, on the other hand, was more inventive with his boomerangs and spear-throwers, and there is no doubt, from his large vocabularies, the construction of his language, his mythology, his explanations of natural phenomena and so on, that he possessed a mental make-up of quite a high order. Obviously intermixture of races should facilitate the variety of advantageous mutations that might be expected, for each race will tend to vary along its own particular lines and with the intermixture all these are pooled. Once a discovery is made, many can use it who could not have invented it. Perhaps one reason why the present day Australian native seems to have been superior to the Tasmanian is, as seems now probable according to Birdsell and Tindale, that he is a mixture of Tasmanian with two or perhaps three other strains as well. The Tasmanians and Australians were clearly physically capable of doing all that Europeans can do, as witness the excellent work done by those who came under white influence. The mental make-up of the Tasmanians probably was deficient in mutations useful to them in their surroundings, but it was in some directions, such as observations in natural history and tracking, of a high order.

Discussion of the second factor, the nature of their surroundings, will occupy most of what I have to say. It may be as well, however, here to dispose of the third factor, the capacity to change with changing environment. The appearance of a hostile race is a factor of supreme importance in this connexion. The autochthones may have to fight these, or may amalgamate with them to a greater or less extent, or may get driven into less desirable regions where conditions are more difficult and fresh experience has to be gained. The Tasmanians probably were driven before the invaders, amalgamating with them to some extent, probably through captured women, along the lines of junction. Those that reached Tasmania were relatively secure. Still another aspect has to be considered. The

blood groups found, only A and O, indicate that the Australian native must have occupied this continent for a very long period of time. It is probable that, during this, great changes in the vegetation have occurred and that a richer fauna and flora were present in the interior of Australia in these early days. Man may have had to modify his activities in many ways as the difficulties in securing food increased with increasing aridity. His existence to-day shows that he overcame these difficulties successfully.

THE ENVIRONMENT IN WHICH THE NATIVE INHABITANTS OF AUSTRALIA AND TASMANIA FOUND THEMSELVES

The first and most important ecological factors for all races of mankind are necessarily food and water. Under primitive conditions, when much time must be consumed in procuring the necessary food, other aspects of the ecology sink into comparative insignificance. It is only later in man's development that geographical features, apart from food supply, play a prominent part as in trade. It thus comes about that our chief subject under this heading deals with the food available to these people and the means they adopted to secure it when it was difficult to come by.

J. W. Bews (1935) has classified mankind in somewhat ascending order into the Food Gatherers, the Plant Cultivators, and the Herdsmen and Pastoral Nomads before we come to the differential activities of highly civilized man. Both the Tasmanians and the Australians belong to the first and most primitive category, that of the Food Gatherers, without any evidence at all of any tendency to pass into the more evolved types. Is their position on the lowest rungs of the human evolutionary ladder purely the result of their mental capacity not having as yet progressed sufficiently far for them to have reached a higher stage, or is this failure to develop in part at least due to the environment in which they found themselves?

Now the mainland of Australia and Tasmania are singularly devoid of edible plants that might lend themselves to plant cultivation, and of animals that could be domesticated so as to develop a race of Herdsmen and Pastoral Nomads.

Though European settlement has now been in existence in Australia for over 150 years, not a single species of plant, with one or two trifling exceptions, has been taken into cultivation as a food plant. Turning to animal sources of food, there is no mammal that could be a source of milk, and the natural pastures would be a much more suitable field for the multiplication of kangaroos and wallabies than any process of domestication and control could be. In other words, the Tasmanian and Australian natives reached a land that gave them no opportunity whatever to practise the arts of plant cultivation or of animal husbandry, even had they possessed a knowledge of such before their arrival.

We are, therefore, in the position to say that, when man reached Australia in those far-off days, he reached a land highly unsuited for the development *ab initio* of a race of Plant Cultivators or one of Herdsmen and Pastoral Nomads, and equally unsuitable for the continuance of such practices had they been acquired elsewhere, unless he had brought with him the necessary plant seeds or roots and the appropriate domestic animals.

Moreover, when they did arrive in the northern coasts of Australia, as castaways or as coastal voyagers, or by a now submerged land bridge, whatever may have been their former status they became Food Gatherers as soon as the

small supply of food they brought with them became exhausted. On such an inhospitable coast, all their energies would be necessarily directed to an incessant daily search for something to eat. Local supplies being soon exhausted, they had to move further afield and no time could have been spared to stay in one place and await the growth of any seed they had planted.

Thus Food and Water at once became the primary factors in their Ecology. All else sank, temporarily at least, into insignificance. Let us first consider their environment from this point of view.

Foods

Ling Roth (1890) and Brough Smyth (1878) give full accounts of the known and possible foods of the Tasmanian natives, whilst many have written on those of the Australians. Time does not permit me to consider these in any detail. I shall merely give a few examples where the collecting of food has unusual ecological relationships or where its preparation may have values which at first sight might pass unnoticed.

Grains. Of the fifty species of Tasmanian grasses given by Leonard Rodway (1903) not a single one of them would be likely to yield grain that could be collected in any quantity, winnowed and ground for food. The same remarks apply to the temperate southern parts of Australia and probably to its eastern coast. These are not the regions for grain production. If the Tasmanians during their wanderings had become acquainted with the use of these grains—and doubtless they had, in parts of Australia—such knowledge was of no further use to them in Tasmania. On the other hand, grasses, differing almost entirely specifically from those in the southern parts, are abundant in the drier interior and some of these, such as several species of panic-grasses, yield a suitable seed.

The grains from grasses and the minute seeds obtained from such plants as species of *Chenopodium* are collected in various ways. Some, such as the seeds of *Portulaca oleracea*, (the munyeroo), are obtained by pulling up the plants and placing them on a rock surface when the upper part of the capsules come apart, setting free the minute black seeds which then can be swept together and transferred to a coolamon for winnowing. The grass seeds may be gathered by hand, but at Macdonald Downs in Central Australia, we were witnesses of a very interesting method of collecting. The panic-grass had been growing on an extensive flat after the summer rains; the grass had become much dried up and beaten down. The grass seeds, however, had been collected together by small black ants and arranged in heaps round the entrances to their nests. To these the native women immediately made their way and filled their coolamons or dishes in a very short time with a mixture of grain, chaff, sand, dust and débris. A hole about one foot in depth was dug with a digging stick in the ground at the base of a mulga tree. Into this the contents of the coolamon were thrown and the native woman then stepped in and de-husked the grain by twisting and turning with her feet, meanwhile supporting herself in part by holding on to the mulga tree (Plate I, fig. 2). This, of course, added much more dirt to the mixture which was now taken out and rocked in the coolamon up and down and to and fro, handfulls being taken up from time to time and let drop, blowing away some of the chaff and dust. By means of these interesting and complicated movements the grain was rapidly separated from the chaff and sand and foreign particles so that, aided by skilful movements of the hand, a sufficiency of grain was soon collected fit for grinding. The grinding was done between two stones, the upper one held in the hand and the grain being in a groove in the larger lower one. A little water

was added as the grinding proceeded. The paste, when ready, was poured into a space in the hot ashes. Several glowing sticks were now suspended over the upper surface of the damper, these being so laid as to form by their heat a protective film on the surface. As soon as this was sufficiently firm the ashes were heaped over so as to cover the damper completely.

One of the most interesting ecological associations was witnessed by Dr. Hackett and Mr. Tindale south of the Musgrave Ranges. Desert currajong seeds were collected by the natives in numbers around the rock holes in the Ranges. The desert currajong (*Brachychiton Gregorii*) grows well out in the sandy country to the south. Crows feed readily on the softer tissue surrounding the seeds, swallowing the seeds as well. The crows make back to watering places and there discharge the seeds in sufficient abundance for them to be collected by the natives and ground between stones to form a meal. One is reminded strikingly of Elijah being fed by the ravens.

Animal Foods. Time does not permit of considering in any detail the animal foods used or the methods employed in obtaining them, important though they be in their ecological relationships. Mammals and birds and birds' eggs formed a most important part of the food of both races. The natives of the Warburton Ranges in Western Australia, when a large kangaroo has to be carried on the head any distance, make a small incision in the abdomen with a sharp stone, take out some coils of intestine, skewer up the opening with a piece of stick, and then truss up the carcass with its limbs and tail into a compact burden using as thongs the intestines after rolling them in the dust. The hair is singed off and the carcass partly buried in and partly covered by hot ashes. In this way all the natural juices with their containing salts are retained and much relished. Such a carcass is rapidly cut up with a stone implement fastened by a gummy substance to the end of a spear-thrower. Each person has his allotted share, depending on tribal relationships. The bones are smashed open and the marrow and pounded bone eaten, the latter helping to maintain the supply of phosphates and calcium.

The Tasmanians, for some unknown reason, did not eat fish, but used shell-fish. The Australians utilized every possible source of animal food. The Tasmanians relished the large white grubs found in dead and dying trees and the eggs of large ants. These large grubs, the larvæ of beetles or moths, known as 'witchitty' grubs or 'bardi' amongst the Australians, were equally relished by the latter. In addition the mainland natives ate lerp scales, coccid secretions from the mulga ('mulga sugar'), large female coccids (*Apiomorphâ*?) in apple-sized galls on eucalypts, termites at the time of swarming, the honey of the honey-ant and other insects and insect products.

Honey. Sweet substances must have been lacking in the diet of both the Tasmanians and the Australians. Various plants, such as Hakeas, Banksias and Grevilleas, often yield abundant honey when the racemes of flowers are drawn through the mouth. The blossoms of *Eremophilas* may be sucked. Fibre from the Liliaceous *Dianella revoluta* may be rolled up in the hand and then drawn up over the honeyed flowers of the Grass-tree (*Xanthorrhoea*), the honey adhering to the fibres. The Australian native bees are stingless and native honeycomb is a great delicacy to the natives of Central Australia. At MacDonald Downs we were shown the method, which proved unusually interesting, of detecting the presence nearby of a native bees' nest. When we had reached a likely locality the natives, instead of looking up in the trees to see the bees possibly entering or departing, got down on their knees and began searching minutely amongst

the sand and particles on the relatively bare earth (Plate I, fig. 1). Soon they were rewarded by finding several very minute, dark particles which had been carried away by the bees from the proximity of their nest and dropped. As it was now certain that there was a bees' nest in the neighbourhood, likely trees were tapped to see if they were hollow and, if necessary, these were climbed, until finally the one harbouring the comb was discovered. After chopping open the hollow a piece of bark was knocked off a neighbouring projection on the tree to form a receptacle into which the honeycomb and entangled bees were placed by the native before he descended. According to tribal custom all those present shared equally in the repast.

The bees that supply honey in any quantity sufficient to be an article of food for man belong to the family Apidae, embracing the Social Bees or Honey Bees. Tillyard (1926) states that all the nine Australian species of this family belong to the genus *Trigona*, very small bees devoid of stings. These bees build in hollows of trees. Rayment adds a single species of the genus *Apis* (*A. aenigmatica*) found by him in Gippsland, which built three tiny combs the size of the palm of one's hand in the open on a verandah. The honey supplies of the Australian natives were obtained from species of *Trigona*. Round Brisbane, Hockings (1884) gives the native name for *T. Cassiae* Ckll. as 'kootchar' and that for *T. carbonaria* Smith as 'keelar' or 'karbi'. Tillyard says that the commonest species *T. carbonaria* is found 'almost everywhere' (i.e. in Australia), but Rayment says our species of the genus are confined to the warm north, *T. carbonaria* being found as far south as Sydney. Ling Roth (1890) does not mention honey as one of the foods used by the natives of Tasmania, but Brough Smyth (1878) says, 'they climbed trees . . . to procure honey, the women carrying with them grass baskets in which they placed their spoil.' The honey-bee, *Apis mellifera* L., was introduced into Australia in 1822 and probably was taken to Tasmania not much later. Brough Smyth's reference therefore possibly may apply to this introduction, though one could hardly imagine an unprotected native attempting to rob the nest of this bee. If a native bee, to what genus does it belong? According to Rayment, it should not be a species of *Trigona*. Is it another species of *Apis*? Are specimens of the bees and their comb available?—

The species we met with in Central Australia was almost certainly a *Trigona*. What is the nature of the small particles left by the bees at a distance of many yards from the site of their comb and searched for on the ground by the natives? These are about 1 mm. in size, irregularly spherical with a mulberry-like surface and very dark, almost black, in colour. I have five of these but do not like to sacrifice any for a possible identification by chemical analysis. Their appearance suggests that they may be resinous. Mr. Womersley thinks it likely that they are particles of propolis, the cement-material used by the bees. But this is valuable and is not likely to be carried away to some distance from the nest. The workers of *Trigona* are small bees only 4 to 6 mm. long, so their individual excreta could hardly be in diameter a quarter to a sixth of their length. However, Rayment (1935) says there is always a busy traffic from the nest carrying out round, flat cakes of brown excrement, which is held by the mandibles and tucked in well under the head. Perhaps the material is a mass of excreta cemented together by propolis.

Water. Water for drinking is, obviously, an essential in the ecological surroundings of man. Man, however, differs from other animals in that, through his mental equipment and ingenuity, he can overcome an environment unfavourable to him in this respect and carry water with him in natural or artificial receptacles.

He may also obtain water from unexpected sources or conserve the supply he has already imbibed.

The Tasmanian native can rarely have felt the lack of water for drinking purposes in Tasmania. As his ancestors probably had inhabited the drier parts of Australia, it is of interest to consider the ways devised by the Australian aborigines for supplementing their supplies of water. Neither the Tasmanian nor the Australian possessed receptacles capable of transporting water over long distances. The Tasmanian made use of the bladders of *Fucus*, or utilized shells, bark, and skulls as receptacles for carrying water to the place of eating. The Australian uses wooden pitchis for a similar purpose, frequently sprinkling a few leaves on the top to lessen the liability to spill. Baler shells are used along the northern coasts. In the drier parts of Australia, the question of a water supply may often far outweigh the importance of food, though the two react on each other. The native can only search for food within a reasonable distance of water. Food supplies are soon exhausted in any locality, and the nomad must then make for another place where water is to be found, where the process is repeated. During the course of a year, a regular round of watering places with their supplies of food are visited, all within the tribal area. In times of drought, water may become scarce, and any possible temporary substitute may have to be employed. Spencer and Gillen (1912) describe the frog *Cheiroleptes platycephalus* and three other species, as swelling up with imbibed water after rains. Then when the rains are over, they aestivate in a chamber in the mud. Such buried frogs the natives can locate, and by compressing the urinary bladder can obtain water which is quite fresh and pure. The Needle Bush (*Hakea leucoptera*) is extensively distributed in the north of South Australia. It has long roots running superficially which can be readily exposed and pulled up. If cut across in short lengths and stood upright in a pitchi, water will drip out of the pores in drinkable amounts.

In the drier mallee areas of Southern Australia an abundant supply of excellent water can be obtained from several species of these eucalypts. Travelling north from Ooldea over a stretch of a hundred miles without any surface waters, the natives successfully cross this dry stage by relying on this source. Water in various quantities can be obtained from the superficially radiating roots of a number of eucalypts even in areas such as Encounter Bay in South Australia where the rainfall is over 20 inches. We have seen it obtained in most quantity from *Eucalyptus transcontinentalis*, perhaps only a variety of *Eucalyptus oleosa*. Radiating from the butt for 30 or 40 feet or more are rounded roots up to an inch or more in diameter. These, near the butt at least, have no rootlets and run an almost straight course outwards. They are only an inch or so below the surface of the more or less sandy soil and can be readily pulled up in lengths of many feet. They are relatively brittle and on examination consist almost entirely within the layer of bark of closely set tubes just visible to the naked eye. Broken into lengths and held vertically aloft over the mouth or on end in a receptacle, water drips freely, sometimes almost in a stream, whilst by blowing at the upper end it gushes and bubbles forth from below. Evidently by its distant ramifications and terminal rootlets, moisture in the sandy soil from even the slightest rain and perhaps from dew fallen from surrounding shrubs is retrieved and passed into the tubes in the bigger roots.

Mr. H. A. Dadswell, of the Division of Forests Products, C.S.I.R., Melbourne, has kindly examined for me specimens of water-bearing roots from *Eucalyptus transcontinentalis* and *Hakea leucoptera* from Ooldea and from *E. fasciculosa* from

Encounter Bay. Cross sections of each were prepared for microscopic examination, and, after making measurements over the whole area of the root, the average percentage available pore area per sq. mm. of area was determined. For *E. transcontinentalis*, a small root 5.5 mm. in diameter gave an average of 32.3 per cent (Plate II), a medium-sized root of 22 mm. 31.6 per cent, and a large root of 27 mm. 33.5 per cent. A root of *H. leucoptera* 15 mm. in diameter gave an average of 34.5 per cent, and one of *E. fasciculosa* 13 mm. in diameter 27.2 per cent.

In discussing these results he writes: 'If we take the medium-sized root of *E. transcontinentalis* and assume that a length of 100 cm. was available, then the available free vessel space (neglecting the small central area) would be able to hold approximately 120 c.c. of liquid'. Thus a root a little less than an inch in diameter and a little more than a yard long could hold about 4 ozs. of liquid. Again a root 30 feet long and an inch in diameter could hold about 94 cubic inches of water. Thus about 3 of these roots could supply a gallon of water if all the fluid could be expelled. This however would not be the case on account of capillary attraction.

Magarey (1895) has given a full account of the sources of water available to the Australian native and of the indications of the likelihood of the presence of surface waters. The sources include rock-holes, soaks, natural hollows in trees, succulent plants and dew collected sometimes by a sponge-like handful of fibre. Open rock holes may be protected from evaporation or contamination by coverings. Certain birds are a sure indication of the proximity of water as are the natives themselves, though in this case the supply may not necessarily be an open one.

Adornment of the Person

Adornment of the person is an essentially human trait. It may take the shape of mutilations, dressing of the hair, clothing apart from, or in addition to, its protective qualities, the use of necklaces, rings and flowers, and the employment of pigments, including tattooing and fats. As examples of mutilations may be mentioned cheloid scars, amputating a digit and cutting the hair or shaving it off or epilating it. The knocking out of one or more teeth probably had, like circumcision and subincision, a deeper significance, though this may have been lost in some cases as in the Musgrave Ranges in South Australia.

I am not aware of any records of other mammals or birds adorning themselves under natural conditions. However, Professor Agar has kindly given me a reference to a most interesting account given by Köhler (1925). He describes how his chimpanzees were fond of hanging ropes, twigs, rags, &c., over their necks, shoulders or ears. He says 'No observer can escape the impression that . . . the objects hanging about the body serve the function of *adornment* in the widest sense. The trotting-about of the apes with objects hanging round them . . . seems to give them a naïve pleasure. Naturally we can scarcely assume that apes have a visual image of what they look like when dressed up like this, and I have never observed their frequent use of reflecting surfaces as in any way connected with their adornment; but it is very likely that primitive adornment like this takes no account of external effect—I do not give the chimpanzees credit for that—but is based entirely on the extraordinary *heightened bodily consciousness of the animal*'.

The natives of Tasmania and of Australia took pains to produce cheloid scars by making incisions which were kept open until granulation tissue had been produced from which the dense scar tissue was derived. The hair of the

Australian sometimes appears as ringlets plastered with grease and mud or may be arranged in a chignon or bun around an artificial core (Plate I, fig. 4). The Tasmanians, according to J. B. Walker (1914, p. 238), wore necklaces of shells strung on twisted kangaroo sinews dyed with red ochre; by treating the shells by burning grass over wood embers, thus producing pyroligneous acid (acetic acid), their outer coverings were removed exposing a surface that yielded prismatic colours. The Australian native uses hair-string, made from human, wallaby, wombat and other sources for various purposes and often as a band around the forehead under which the flowers of Cassias and other plants may be tucked. Girls and young women may insert the tips of slender locks of hair into the capsules or buds of Eucalypts giving quite a picturesque appearance as they dangle (Plate I, fig. 3).

Péron (1809, p. 196) gives a graphic account of his meeting with a group of Tasmanian women. These 'with the exception of some few who had the skin of a kangaroo over their shoulders, were all entirely naked . . . Their black skin disgustingly greased with the fat of the sea-wolf, their short woolly hair, which was black and dirty, and which some of them had powdered with red ochre; their figure besmeared with the dust of charcoal; their shape generally lean and shrivelled . . . in a word, all the particulars of their natural constitution were in the highest degree disgusting'.

Red ochre, yellow ochre and white earthy pigments are extensively employed amongst the Australian natives, either in the shape of definite designs or sometimes applied indiscriminately. Charcoal also may be used, as it was by the Tasmanians. In the central parts of Australia there is to be found a stalked puff-ball, *Podaxon pistillaris*, the stalk of which is surmounted by a fusiform fruiting body. The exoperidium can readily be removed from this like a glove from the finger, leaving behind a dark purplish-fuscos mass of spores. Holding the base of the stalk in his hand the native may apply this purplish mass liberally to the cheeks and nose much as face powder is employed by Europeans; in both cases a 'flesh-coloured' tint is applied.

The down of birds lends itself to decorative purposes, especially that of the eagle. It is extensively used for ceremonial purposes being stuck on to the body by means of the sticky serum that exudes from the clotting of human blood. To obtain this blood, the men readily open the veins of the arm by means of a short longitudinal incision with a sharp pointed piece of stone, often prepared on the spot. Recently at Ooldea some of the younger men were wearing long feathers, such as those of the bustard or native turkey, tucked into the hair arranged as a chignon. These plumes waving about had quite a picturesque effect. Other instances of adornment consist of placing sticks through a perforation in the septum of the nose (Plate I, fig. 4), and often flowers may be inserted in this way.

Adhesive Substances

Adhesive substances are of very obvious importance to primitive peoples. Their non-use may mean either that their practical applications have not been realized or that the requisite materials are not available. The sticky serum from clotted blood is mentioned elsewhere as being used for applying eagle down to the surface of the body or to materials used for ceremonial purposes. The adhesive substances, however, which chiefly concern us are those employed in making or hafting weapons and tools. In the central parts of Australia various gummy and resinous substances are in general employment for fixing stone flakes at, for instance, one end of a spear-thrower to form a small adze, or for the

purpose of helping to fix an axe head on a cleft stick, or to support wallaby tendons in attaching the spear point to the end of a long light shaft, and for other similar purposes. One of the best and most abundant sources of this kind of substance is a species of porcupine grass (*Triodia*), the plant referred to by explorers usually as 'spinifex'. Most of the *Triodias* have a resinous material between and around the bases of the leaves. This is, in some species, so sticky that occasionally birds may lose feathers from coming in contact with it. It also gives rise to a fierce flame when the porcupine grass is burnt. Considerable quantities can be collected by the natives and made into flat cakes of a dark colour. These can be readily melted and soon set firmly again.

On the Diamantina we were surprised to find that mindry gum was obtained from the roots of *Leschenaultia divaricata*, one of the Goodeniaceae. Gum from *Myoporum platycarpum* (False Sandalwood) and from grass-trees (*Xanthorrhoea*) are also employed in more southern parts, but these materials seem more brittle and less useful. There seems no evidence of the employment of such adhesive substances by the Tasmanian natives. This is probably due to the absence of suitable material. Though grass-tree gum is used on the mainland, it does not seem very successful, and its use there may have been merely an attempt at copying the more successful gum substances of the interior. I cannot recall any other vegetable product in Tasmania that would be likely to lend itself for this purpose.

THE NATIVE'S CONTROL OF HIS ENVIRONMENT

A little consideration will show that the natives of Tasmania and Australia exercised but little influence over their environment, whilst more advanced races controlled their surroundings by clearing forest lands and planting crops, by growing fruit-trees and vegetables and domesticating useful animals. In great part our natives, through no fault of their own, did none of these. Though the control of their food supply by cultivation was negligible and the breeding of useful animals non-existent, they were nevertheless under the firm conviction that by increase ceremonies and tabus they were actually in control of these supplies and able to affect their abundance.

Control of Temperature

The most interesting aspect of his control of his environment is, however, seen in the ways he overcame the effects of low temperatures and secured for himself a sufficiency of warmth in cold weather. We therefore have to consider his control of the temperature to serve his ends or even to make continued existence possible.

Climate is naturally one of the most important ecological agents affecting man, as also other animals and plants. When in the course of evolution, various vertebrates emerged from the waters in which their ancestors had developed, they overcame the difficulty in change of environment by devices which really meant that they carried their essential original surroundings with them. With the coming of warm-blooded creatures, mammals and birds, a suitable temperature was maintained throughout with consequent better control over the environment. Feathers or a hairy covering conserved heat during cold periods. Man's natural covering of hair is so poor, however, that it can serve him but little as a protection against cold. The utilisation of the skins of animals for purposes of warmth was a discovery of much moment to him. Nevertheless as a nomad such an added burden of weight might at times be a handicap. The making of breakwinds and shelters doubtless preceded the making of garments. Finally came the discovery of fire

as a means of warmth and later for cooking. Shelters, clothing and fire enabled primitive man to extend his range to colder regions—by means of these devices the environment was controlled so as not to be injurious to him. How did the Tasmanian and Australian natives fare in this regard? No clothing of any kind is worn by the natives—men, women and children—in Central Australia. In the more southern parts and in Tasmania, the skins of animals were sometimes used, but the amount of warmth thus obtained cannot have been great, and in the case of the Tasmanian women it is considered that the skins were chiefly used to support the infants. Fire has been the chief means for mitigating the effects of cold. The native of Australia invariably carries a firestick with him, which in cold weather gives a little warmth, waved in front of his body and with which he may frequently set fire to tussocks of porcupine grass and bushes and warm himself at the blaze. At night he sleeps behind a breakwind with a little fire on each side of him and often another at his feet. Sir Stanton Hicks and W. J. O'Connor (1938) have carried out a number of investigations on the heat regulation of the Australian natives under cold conditions. They find that, as a result of the use of these small fires, to which the native is able to lie very close, areas of high skin temperatures are to be found on the body of the sleeping native. They believe that in this way a considerable amount of radiant heat is absorbed, which counter-balances to some extent the loss from those parts intensely cold. Moreover the aboriginal has an extremely active control over the blood circulation in his skin so that heat loss from a cold part is minimized by a diminution of circulation through that part. In contrast with the clothed European, whose metabolism is increased when he is cold, so that more fuel is used to warm him, the native does not show any such increase. Where food supplies may be precarious, this conservation is an interesting finding, there being no needless waste of food income merely for the purposes of warmth. Thus the chief means adopted for maintaining the body warmth during cold weather and especially at night consist of breakwinds, small fires yielding considerable radiant energy, and such a local control over the blood circulating in the skin that those parts exposed to the cold lose as little heat as possible through a diminished circulation through them.

THE EFFECTS OF HIS EXTERNAL ENVIRONMENT ON MAN

Teeth

Absence of Caries. The infrequency of caries of the teeth in Tasmanian (Wunderly, 1939, p. 331) and Australian (Campbell, 1939) natives is well known and at once obvious on examining any collection of skulls. Campbell has fully dealt with the Australian aspect. Decalcification of the enamel apparently can only be achieved by the action of acid. A sticky, fermentable carbohydrate glued on to the teeth may there undergo an acid fermentation and the concentration of acid may be sufficiently great to lead to decalcification; in this way decay originates. Living under natural Australian and Tasmanian conditions glutinous food-stuffs are negligible in amount, and even where grains are ground the resulting flour is so coarse that the food does not tend to become adherent around the teeth. The fibrous, stringy and tough nature of much of the food also exercises a detergent effect, reducing again the risk of caries.

Attrition, or grinding down of the teeth, is a striking feature in Australian and Tasmanian skulls. Sometimes by middle life the teeth are so ground down as to be on the level with the gums, the pulp chamber having been obliterated by the formation of secondary dentine as the attrition proceeded. This grinding

away of the teeth is attributable to the incorporation of much sand and grit in food-stuffs consumed in the open and to the separation of small stone particles in grinding grain in the hand mills. In addition much masticatory effort is required in dealing with foods which are often tough and fibrous. F. St. J. Steadman (1937), in a recent examination of 52 Tasmanian skulls in collections in England, states that a very striking feature was the marked and almost universal attrition. Dr. W. Crowther has kindly supplied me with notes on the degree of attrition in Tasmanian skulls in his own possession and in the Tasmanian Museum. He finds that this condition is frequent, though the degree, perhaps, is not so great as in some Australian skulls.

Intoxicating Beverages and Narcotics

These might be considered under the caption of food, but they seem more appropriate when considering the effects of his external environment on man. The Tasmanian natives obtained a fermented drink from the saccharine sap which exudes at certain seasons from the Ribbony or Cider gum. Holes were ground into the trunk, and the juice that flowed from the apertures was collected in a hole at the foot of the tree and allowed to ferment.

On the mainland of Australia, two Solanaceous genera of plants, *Nicotiana* and *Duboisia*, include species with narcotic properties, used by the natives. Neither genus occurs in Tasmania, and in fact there are there only two species altogether of this family, namely *Solanum aviculare* and *Solanum nigrum*. The Tasmanian aborigines had therefore no chance of using narcotics, though this Society has an interesting association with the famous pituri or pitcherry of Australia. Morris (1898) gives the earliest reference to the employment of the word pitcherry as being in the Proceedings of this Society for April, 1863, p. 1, when W. Johnston presented nardoo 'seed' and pitcherry. The wording is "Pitcherry", a narcotic plant brought by King, the explorer, from the interior of Australia, where it is used by the natives to produce intoxication . . . In appearance it resembled the stem and leaves of a small plant partly rubbed into a coarse powder . . . On one occasion, Mr. King swallowed a small pinch of the powder, and described its effects as being almost identical with those produced by a large quantity of spirits.'

Morris was, however, not correct in his statement that the first printed use of the word 'pitcherry' was in these Proceedings as Wills in his diary, dated May 7, 1861, referred to 'bedgery or pedgery' (other spellings for pitcherry) and this diary was published in 1861 and again in 1862 and 1863. Pituri (this seems to be the most appropriate spelling) consists of the twigs and dried leaves of *Duboisia Hopwoodii* gathered somewhere in the neighbourhood of the upper parts of the Mulligan River near the South-west corner of Queensland. It was traded extensively to the natives along the Diamantina and thence even down to the Flinders Ranges and eastwards along the Cooper (Johnston and Cleland, 1933-34). Coming from afar by barter to these southern tribes, it had a glamour about it which helped doubtless to mask its origin. Bushes of *Duboisia* grow at Bellamy's Well, about 70 miles west of Lake Torrens, and yet this nearer source for the leaves and twigs was not realised by the natives of the district or those of the Flinders Ranges. Moreover the plant grows abundantly in the sandhill country of Central Australia, where it is used for stupefying emus by placing small quantities in the rockholes where they come to drink. In these parts it is not used at all by man or at most only occasionally when another narcotic supply, the leaves of several species of true tobacco (*Nicotiana* spp.), are running short or

not available. This latter source is of unusual interest. With the possible exception of New Guinea, America and Australia are the only parts of the world where species of *Nicotiana* are indigenous. In both regions, the native inhabitants have discovered their narcotic effects and prize them highly in consequence. Fifteen species have already been described from Australia (Wheeler, 1935). Of these we have personally observed the use of four (*Nicotiana excelsior*, *N. Gossei*, *N. ingulba*, and *N. Benthamiana*), whilst other species, often similar in general appearance, are discarded. Their employment for chewing extends at least from the Musgrave Ranges (south of 26° Lat.) in the N.W. of South Australia to the whole extent of the MacDonnell Ranges and as far north as the Granites in the extreme west of the Northern Territory near the parallel of 20.6° Lat. The leaves, fresh or dried, are chewed into a bolus which is parked when not in use behind the ear where it is readily available for personal use or that of a friend. From time to time it is rubbed in the fine wood ashes obtained by burning small twigs of several species of *Acacia*, especially *A. ligulata*, the alkaline ash accentuating the liberation of the alkaloid nicotine. Chewing is the only method the natives employ in using it though European tobacco may be smoked in a pipe or cigarette or chewed. The pre-European American Indians apparently smoked their tobacco in pipes or as cigars, inhaled it as snuff and chewed it as well. There can be no doubt that the use of indigenous species of *Nicotiana* by the Australian natives antedated any European influence.

CHANGES WROUGHT IN THE ENVIRONMENT THROUGH THE AGENCY OF MAN

Destructive Wood-Infesting Grubs Eaten by Natives

Civilized man has made remarkable and, in some cases, lamentable, changes in his environment. What changes in their environment can we attribute to the natives of Tasmania and Australia?

For the purposes of this discussion we can consider them together, and our analysis will show that these food-gatherers exercised extraordinarily little permanent effect on their surroundings. There was no tilling of the soil and consequently no clearing of the original vegetation of the land. With the exception of the dingo kept by the Australian native, there were no domesticated animals at all, and so no flocks and herds to play their part in altering the country-side. The nomadic character of the Australian aborigine did not lend itself to the serious depletion of the vegetable and animal foods on which these people depended, so that a balanced position was attained. We have no reason to think that any species of animal or plant disappeared as a result of its use as food by the natives.

They did, however, exercise some control by extracting the large white witchetty or bardi grubs of certain beetles and moths found in the stems and roots of a number of native trees and shrubs. Since the introduction of the rabbit the Australian native has been playing quite an important role in its control.

Effects of Fire

Both the Tasmanian and the Australian natives were able to make fire and habitually used it. The Australian and Tasmanian vegetation is remarkably resistant to exposure to fire. Many shrubs and trees sprout again, and the effect of these fires is to produce a very considerable seed-bed. Is there any evidence that this recovery from fire is a result of the evolution of fire-

resistant types of plants? Information supplied to me by the Conservator of Forests in South Australia, Mr. G. J. Rodger, shows that forest fires from lightning may occur not infrequently. Before the coming of man, however, such fires, occurring only after long intervals, probably exercised little influence on the vegetation. When man came, however, accompanied in his wanderings by fire, which he either carried with him or made by the 'sawing method' or the 'twirling method' as occasion demanded, accidental fires were probably frequent, though a recent writer in 'Nature' doubts whether this was the case. It is quite possible that the frequent occurrence of fires has led to the disappearance of some species of plants, perhaps numerically few, which were unusually susceptible to it. We have, of course, no means of ascertaining how many kinds of plants have disappeared in this way. Any alteration in the appearance of the vegetation from this cause is as nothing compared with the effects of clearing the land and grazing produced by Europeans. In Tasmania, however, James B. Walker (1914) describes open plains formerly known as favourite resorts of the blacks which subsequently became overgrown with forest during the discontinuance of their annual burnings. Dr. D. A. Herbert (1938) suggests that certain grassy areas interspersed with rain forest in the Bunya Mountains in Queensland were the result of fires produced by the blacks. Taking them altogether it will be seen that the changes wrought in the environment through the agency of primitive man in Australia and Tasmania are almost negligible.

THE EFFECTS OF THE ENVIRONMENT MAN BROUGHT WITH HIM TO AUSTRALIA

Parasites and Disease

In considering the ecology of man, one must not overlook that intimate environment that he himself carries with him, an environment in which parasitic and saprophytic organisms may flourish and the former be responsible for disease. The parasitic organisms themselves may possess a relatively simple life-history associated almost entirely with man, as in the case of head-lice and such viruses as those of poliomyelitis and epidemic influenza; or the life cycle may be a complicated one, involving intermediate hosts, which in their turn may be dependent on specialized conditions as in malaria and yellow fever, sleeping sickness and hydatid disease. It is unnecessary to dwell on the toll on human life that some of these diseases may take. What part have such organisms played in the lives of the Australian and Tasmanian natives in the pre-European era?

Early vocabularies, both Australian (Brough Smyth, 1878) and Tasmanian (Ling Roth, 1890), give native words for the louse, presumably the head louse of man. These early references indicate that these creatures accompanied both races when they reached Australia. We can say definitely that the Australian native was not the host for any helminth (worm) parasites before contact with Europeans. Both the Australian and Tasmanian natives readily acquired European infective diseases when exposed to them, and many died in consequence. The scattered nature of the population and the infrequent intercourse between tribes led, however, to the almost complete absence of epidemic and infectious diseases amongst the original inhabitants; whatever they may have brought with them, with one or two possible exceptions, died out in consequence of these difficulties.

It is doubtful whether they suffered from infectious colds, and they certainly did not suffer from tuberculosis, measles and other similar diseases before the coming of the white man.

Nevertheless they did suffer from two important diseases. In 1789, a little more than a year after the First Fleet reached Port Jackson, natives were found dying in considerable numbers in rock shelters and other situations round the Harbour from an eruptive disease which was considered to be smallpox. Brough Smyth (1878), in a statement to which, perhaps, little credence can be attached, says that it is conjectured that prior to the colonization of Tasmania a large number of persons had been carried off by smallpox. Smallpox amongst the Australian natives swept across Australia in three waves of which there are records (Cleland, 1928). Apparently it had been introduced on each occasion along the northern coastline, probably by Malay trepang fishers.

The other disease is yaws, which Dr. C. Hackett (1938) has shown to be widely spread in Central and Northern Australia and probably occurred throughout it. It is possible, though not probable, that certain references to skin conditions in the Tasmanians may have been to yaws. The infection of yaws is spread by accidental contact, direct or indirect, from open sores in which the spirochaetes may be abundant. The native is unclothed, so that all sores are exposed freely to the air, and anyone who has paid a visit to the warmer parts of Australia in summertime knows how abundant flies are and how they cluster round the eyes and mouth and especially round any sore with a moist surface. Quite obviously flies are a ready means of transmitting the infection from one case to another, and flies consequently have played quite an important role in the ecology of the Australian native, and possibly also in the Tasmanian.

Captain Dampier (1697, p. 282), writing of the natives of the North-west of Australia, described them as being the 'miserablest people in the world. The Hodmadods of Monomatapa, though a nasty people, yet for wealth are gentlemen to these.' In describing their appearance he goes on to say that 'their eyelids are always half-closed, to keep the flies out of their eyes, they being so troublesome here that no fanning will keep them from coming to one's face; and without the assistance of both hands to keep them off, they will creep into one's nostrils, and mouth too, if the lips are not shut very close. So that from their infancy, being thus annoyed with these insects, they do never open their eyes as other people, and therefore they cannot see far, unless they hold up their heads, as if they were looking at somewhat over them.'

This graphic description by Dampier is as true to-day in Central Australia as it was in his day. The fly concerned is a native fly, *Musca vetustissima*. We all know how persistent it is when we go for a walk through the bush in summertime, the flies being so troublesome that no fanning will keep them from coming to one's face. They take every opportunity of abstracting moisture and nutriment from the tears in the corners of the eyes and the saliva round the mouth, and the blood from any recent scratch. One can readily see, therefore, that the infection of 'erkinija' the native name for yaws can be spread by these persistent creatures from an infected sore in one child to a scratch on another.

This species of fly is indigenous to Australia, and strange to say has not yet acquired the habit of entering into our houses, although they may enter more or less open tents. The flies that occur indoors are introduced species, more particularly *Musca domestica*. As a result of these differences in habits, the bush fly plays little part in the spread of typhoid fever in Australian communities, whereas the domestic fly is undoubtedly frequently responsible.

SUMMARY AND CONCLUSION

In this brief survey some aspects only of the ecology of primitive man in Tasmania and Australia have been considered. No reference has been made to his implements, handicrafts and art, or to the sources and nature of the materials used for these purposes; none to the Australian native's interpretation of natural objects as representing the doings of ancestral beings; none to the skill in tracking and hunting game or to the habits as they affect the hunter of the animals so hunted; none to many other sides of the complicated relationships that exist between man and his natural surroundings. I have merely taken some aspects that have appealed to me particularly as a naturalist and many of which I think would have appealed to Clive Lord also. I have tried to show that the country to which these peoples came was neither literally nor metaphorically flowing with milk and honey. Nevertheless they overcame with remarkable success the difficulties that presented themselves and obtained food and water often from unusual sources and in unexpected ways. I have shown that through the absence of suitable plants to cultivate and animals to domesticate they could not control their environment by growing food-stuffs or keeping flocks and herds and so remained or became food-gatherers only. Though often destitute of coverings and so going naked by day and night, their skilful use of little fires and physiological changes that sophisticated man has lost have enabled them to control the deleterious factor of cold. One important effect of the environment has been the grinding down of the teeth through the frequent incorporation of sand and grit in the diet and the fibrous nature of much of the food; the use of native tobacco and pituri as narcotics has also been mentioned. Fire has been the only means by which they have altered their environment and that probably only to a trifling extent. Epidemic diseases for reasons stated were almost non-existent.

In conclusion, may I say that the Australian native is a very likeable being, as doubtless was the Tasmanian. The latter has passed away as a pure race and the former, I regret to say, seems to be passing away too. Civilization seems to have been fatal to each; with detribalization, the interest in life ceases. Removed from their own country with its ancestral associations they languish and die. Grave wrongs have been done to many. But even kindness and fostering care and patient endeavour have proved unable to stem the tide of decay. Through all the ages have descended the bloods of these two ancient races of man, of man who is the acme of evolution. In the clash of worldly interests, I see little hope for the continued existence of the pure-blood Australian native beyond a few scores of years. But of both races there are descendants of mixed blood. The aboriginal element in them, I am convinced, is by no means an undesirable one. The same may be said of the European side, when it came from sturdy pioneering stock. The task before us now, in Tasmania and in Australia, is not to keep these folk segregated, but to fit them for taking their place in our social organization. There can be no other solution. Gradually absorption will occur, and thus the blood of the ancient Tasmanian and Australian races will, I trust, live on in the veins of some at least of our successors in this Island and in this Commonwealth, and not to their disadvantage.

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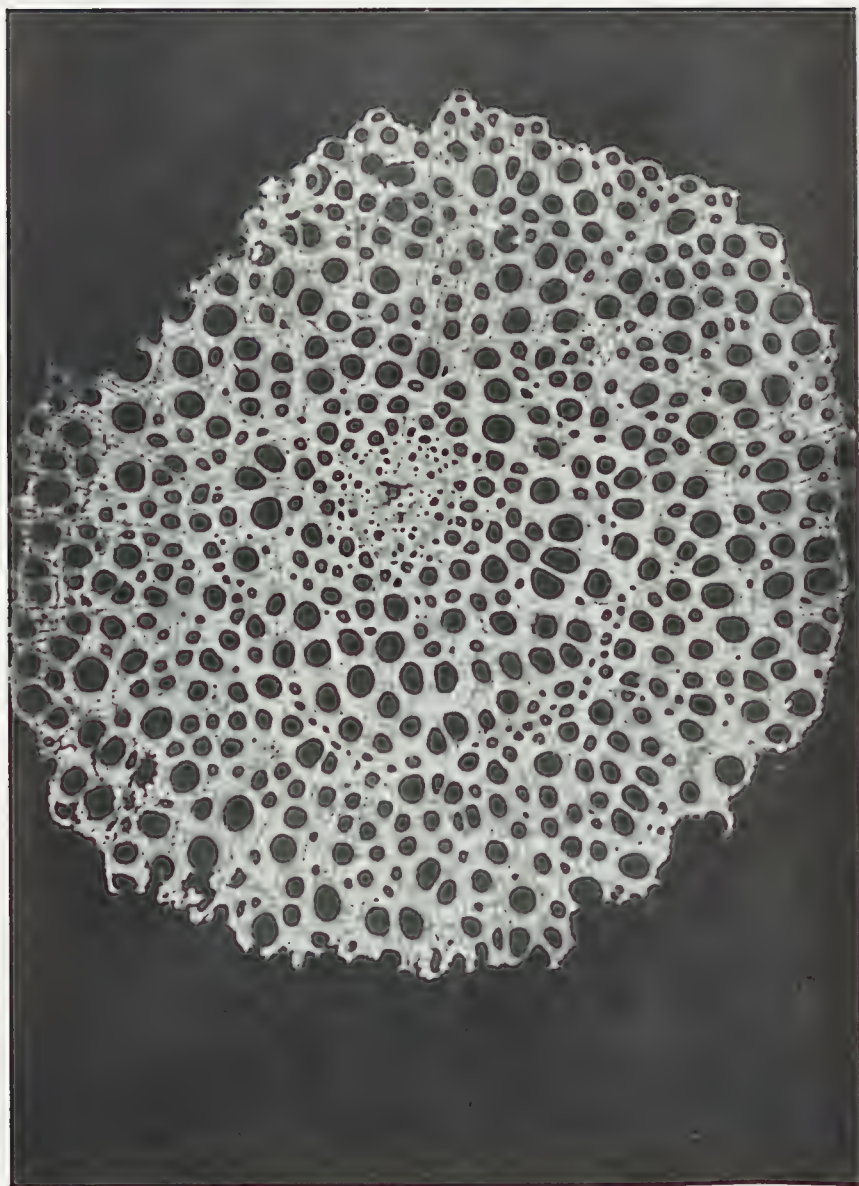
PLATE I

- FIG. 1.—Looking for a bees' nest. Men and boys searching the ground for small dark particles 1 mm. diameter, carried away from the nest by the bees. If found, they indicate that a bees' nest is near. Macdonald Downs, Central Australia. (Photo by Professor T. Harvey Johnston.)
- FIG. 2.—Woman dehussing grain by movements of the feet in a hole in the ground. She is partly supporting herself against a mulga stem. Macdonald Downs, Central Australia. (Photo by Professor Wilkinson.)
- FIG. 3.—Adornment of the Person. Young woman with the tips of strands of hair forced into the orifices of 'gum nuts' (*Eucalyptus* capsules). Warburton Ranges, W. Australia. (Photo by O. Stocker.)
- FIG. 4.—Adornment of the Person. Young man with hair arranged in a chignon and cheloid body scars. Another with a bone placed through a hole in the nasal septum. Mt. Liebig, Central Australia. (Photo by Professor T. Harvey Johnston.)



PLATE II

Small water-bearing root of the Mallee *Eucalyptus transcontinentalis*, 5.5 mm. diam. The available pore area is 32.3 per cent. Ooldea, S. Australia. (Photo. by H. E. Dadswell, Division of Forest Products, C.S.I.R., Melbourne).



NATIONAL MUSEUM OF VICTORIA

Notes on the systematics of two species of *Heterodoxus* (Mallophaga, Boopidae)

By

N. J. B. PLOMLEY, B.Sc.

(Read 13th November, 1939)

PLATES III-VI

The problems here considered are, first, the systematics of the lice of the genus *Heterodoxus* Le Souëf and Bullen, occurring on the domestic dog and certain other monodelphian mammals, and, secondly, the question of their identity with members of the genus occurring on didelphian mammals (marsupials). Upon marsupials, apparently the true hosts, the genus appears to be confined to the Macropodidae.

DIAGNOSIS OF SPECIES; HOST RECORDS

Genus *Heterodoxus* Le Souëf and Bullen

Heterodoxus longitarsus (Piaget). Genotype

Menopon longitarsus Piaget (1880), pp. 504-506, pl. XLI, f. 7; *Halmaturus giganteus*, (Zoo. Rotterdam).

Heterodoxus macropus Le Souëf and Bullen (1902), p. 159, f. 11; 'Kangaroos, Wallabies, &c.'.

Type host: *Halmaturus giganteus* = *Macropus major* (Shaw).

Notes: The Piaget Collection in the British Museum (Natural History) includes four slides marked '*Menopon longitarsus*', a total of 3 ♂♂, 3 ♀♀, 3 ☉☉. Two slides, with 1 ♂, 1 ♀ mounted on each, are labelled '*Menopon longitarsus*, sur un Kangourou, *Halmaturus giganteus*', the other slides, '*Menopon longitarsus*, sur un Kangourou'; the former are to be considered the types since a definite host is designated.

Unfortunately, I have not been able to examine these specimens critically, nor have I been able to obtain any material from the type host. Since it is more than likely that *Heterodoxus* will show definite host specificity, I consider that *Heterodoxus longitarsus* (Piaget) from *Macropus major* (Shaw), is a definite species and distinct from *H. spiniger* (Enderlein) and from *H. ualabati*, sp. nov.

Heterodoxus spiniger (Enderlein)

Menopon spiniger Enderlein, (1909), pp. 80-81, pl. VIII, f. 4, 5; ('von Haushund eines Betschuanen, auf den es wohl von einem Beuteltiere gelangt ist.')

Heterodoxus armiferus Paine, (1912), p. 362, f. A-D; (dog).

Heterodoxus longitarsus auctorem (non-marsupial hosts).

Type Host: 'Haushund' = *Canis familiaris* Linné.

Hosts: (A) Marsupial: *Wallabia bicolor* (Desmarest); (B) Non-marsupial: *Canis ochropus* Eschscholtz ('Coyote'), *Herpailurus salinarum* Thomas ('*Oncifelis salinarum*') 'Jackal', 'Man', *Canis familiaris* Linné.

Specimens examined: *Note*:—Certain of these specimens are those upon which previous authors have based descriptions, records, &c., and are indicated accordingly.

'Jackal', Uganda, Arua, 2.iii.1931, T. W. Chorley, 1 ♂, 2 ♀♀; '*Canis famil.* (juv.)', Belgian Congo, Katanga, Bukama, 18.x.1931 series ♂♂, ♀♀; 'Cocker Spaniel', Tasmania, Launceston, 24.i.1934, N. J. B. Plomley, 1 ♂, 2 ♀♀; 'Dogs', Dutch New Guinea, Geelvink Bai, iv.1929, Malte von Kuhlewein, 1 ♂, 3 ♀♀; 'Puppies', Australia, N.S.Wales, Gulargambont 18.vi.1933, R. N. McCulloch, 1 ♂, 1 ♀, 1 ♂ (McCulloch, (1933)); 'Dog', Japan, Yokohama, 24.iv.1902, 1 ♀; 'Dog', China, Hangchow, 1 ♀; 'Dog', Brasil, Rio de Janeiro, 2 ♂♂, 5 ♀♀; 'Dogs', Malaya, Kelantan, Kota Bharu, 12.xi.1912, 1 ♂, 1 ♀; 'Dog', Dutch New Guinea, N. coast Schoutein Is., Warsa, 1.ii.1930, M. von Kuhlewein, 2 ♂♂, 7 ♀♀; *Wallabia bicolor* (Desmarest), Australia, Victoria, 2 ♂♂; 'Coyote', U.S.A., California, Santa Cruz, 1916, G. F. Ferris, 1 ♂, 1 ♀ (Ferris (1922)); 'Dog', U.S.A., California, Berkeley, 7.x.1909, Herms, 1 ♂, 1 ♀ (types *Heterodoxus armiferus* Paine) (Paine (1912)); 'Man', Fed. Malay States, Kuala Lumpur, xi.1915, S. T. Darling, 1 ♀ (Ferris (1922)); 'Domestic Dog', Columbia, Villeta Dept., Cundinamarca, 1936, J. Bequaert, 1 ♂; 'Dog', Hawaii, Honolulu, 15.iii.1933, C. E. Pemberton, 1 ♂, 2 ♀♀; 'Dog', Java, Toeloengogoeng, 21.ix.1932, C. J. Louwerens, 4 ♂♂, 1 ♀; 'Dog', Java, Toeloengogoeng, 6.x.1932, C. J. Louwerens, 2 ♂♂, 1 ♀; 'Dog', Cuba, Havana, 6.x.1932, Dr. Terez Vigueira, 3 ♂♂; 'Off large, black, short-haired, adult ♀ dog', Canal Zone, R. Chagres, Gatuncillo, 19.i.1932, L. H. Dunn, 1 ♂, 1 ♀; *Oncifelis salinarum*, Argentina, Jujuy, F. L. Werneck, 1 ♂, 1 ♀ (Werneck (1936)); 'Dog', U.S.A., Missouri, State College, iv.1935, F. W. Stafford, 5 ♂♂, 5 ♀♀; 'Dog', U.S.A., Oklahoma City, 5.vi.1933, J. W. Ward, 1 ♂, 1 ♀ (Ward (1934)); *Canis familiaris*, S. Africa, Kalahari, 1910, (error = 1904), 1 ♀ (type *Menopon spiniger* Enderlein) (Enderlein (1909)); 'Chien Terre Neuve', Martinique, i.1896, 1 ♀ (Neumann (1912b)); 'Chien', Japan, Yokohama, 1909, C. N. Rothschild, 1 ♂, 1 ♀ (Neumann (1912b)); *Canis familiaris*, Formosa, Kosempo, vii.1911, 1 ♂, 1 ♀ (Neumann (1913)); *Canis familiaris*, Malay Peninsula, xi.1912, Dr. Gimlette, 1 ♀ (Neumann (1913)); 'Chien de laboratoire', Mozambique, Lourenço Marques, 9.iv.1910, Howard, 2 ♂♂, 1 ♀ (Neumann (1912b)); 'Dog', Australia, Queensland, Goondiwindi, 28.v.1936, F. H. S. Roberts, 3 ♂♂, 11 ♀♀, 6 ♂♂ (Roberts (1936)); 'Dog', India, Calcutta School of Tropical Medicine, 63 ♂♂, 74 ♀♀, 59 ♂♂; 'Dog', Porto Rico, Mayaguez, 22.iv.1936, 22 ♂♂, 43 ♀♀, 10 ♂♂.

Diagnosis. General facies typical of genus. Plate III, figs. A-J; Plate IV, figs. A-B, D-K; Plate V, figs. A, C-G; Plate VI, figs. B, C: show details of head, thorax and abdomen; Table 1 gives an analysis of measurements and counts. Distinguished from other species on the structure of the phallus in the male. Posterior border of tergite of last abdominal segment in ♂ bears 12-63 (S.D.n-1 = 1.54) spines, that of last abdominal sternite in ♀ 17-77 (S.D.n-1 = 1.75) spines; the setae are arranged in a discontinuous band or nearly so in both sexes, there being a median gap in the row dividing it right and left. Metathoracic sternal sclerite bears six setae, with intersetal distances as tabled. Setae arranged on metathoracic tergite as figured.

Heterodoxus ualabati sp. nov.

♂ *Heterodoxus macropus* Paine (1912) (nec Le Souëf and Bullen, (1902)), p. 361, f. E-G; 'Black Wallaby'.

? *Heterodoxus longitarsus* Harrison and Johnston (1916) (nec Piaget, (1880)), f. 11; *Macropus dorsalis* (= *Wallabia dorsalis* (Gray)).

Type Host: 'Black Wallaby', Victoria = *Wallabia bicolor* (Desmarest) ⁽¹⁾.

Specimens examined: 'Black Wallaby', Victoria, A. S. Le Souëf, 2 ♂♂, ("type specimens" *Heterodoxus macropus* Paine) (Paine (1912)); *Wallabia bicolor* (Desmarest), Sydney Zoo, 10.v.1927, 5 ♂♂; *Wallabia bicolor* (Desmarest), Victoria, 4 ♂♂.

Diagnosis. General facies typical of genus. Plate III, fig. K; Plate IV, figs. (A), C, (E), L; Plate V, figs. (A), B, H; Plate VI, fig. A: show details of head, thorax and abdomen. Table 1 gives an analysis of measurements and counts. Distinguished from other species on the structure of the phallus in the male. Posterior border of tergite of last abdominal segment in ♂ bears about 22 spines, arranged in a continuous band. Metathoracic sternal sclerite bears six setae, with intersetal distances as tabled. Setae arranged on metathoracic tergite as figured. Female not known.

DESCRIPTION

Head. Shape conical, bluntly rounded anteriorly and the postero-lateral angles acute. Chaetotaxy very constant in disposition, but setae subject to some variation in relative length and strength. Plate III shows these features for a number of individuals of *H. spiniger* and *H. ualabati*. The head structure appears generically constant.

Thorax. Plate IV, figs. A, E show dorsal and ventral views of the thorax of an *H. spiniger*; the thorax has a similar structure in *H. ualabati*, and, except for the chaetotaxy of the metathorax, appears to be generically constant. Three segments are to be distinguished dorsally and ventrally. The chaetotaxy of the prothoracic and mesothoracic tergites is constant, that of their sternites variable. The prothoracic tergite is an oval plate (Plate IV, figs. A-C); on the sternite is a heart-shaped sclerite ⁽²⁾ bearing a number of setae (Plate IV, figs. E-H). These setae comprise:—(1) a series of three on each side (Plate IV, fig. F, 'x', 'y', 'z'), which are of almost constant occurrence, and (2) others of very variable disposition, though they show some tendency to comprise a few longer setae posteriorly and a row of shorter ones anteriorly. The width of this plate (see Table 1, intersetal distance 'xx') is expressed by the distance between the two anterior spines 'x'.

The mesothorax is poorly developed dorsally, where it bears only a pair of spines; ventrally it is more extensive, and bears a variable number of spines, which show little regularity of arrangement though a tendency to occur in two bands which diverge anteriorly.

The metathoracic tergite is of rectangular shape (Plate IV, figs. A, D). In *H. spiniger* and *H. ualabati* (♂) it bears posteriorly a median pair of long hairs with a pair of short spines at the lateral angles, and centrally a row of six long setae with some short ones laterally. In both species the sternum bears an ill-defined plate upon which there are three pairs of setae, the occurrence and disposition of which are very constant; only very occasionally are extraneous setae present (Plate IV, figs. E, I-L).

(1) Personal communication from Mr. A. S. Le Souëf.

(2) The pair of hairs situated at the anterior margin of the sclerite, sometimes included in it and sometimes outside it, and the similar pair between the plate and the mesothorax, occur regularly. They are not considered in counts for Table 1.

Abdomen. (Plate V, fig. A). The tergum, sternum and pleura of each segment bear setae, those of the tergum tending to be merged with those of the pleura. The spiracles are dorso-lateral; on segments 1-3 there are dorso-lateral sense organs (Plate IV, fig. A; Plate V, fig. A; 'so'). Though the lengths of the setae intergrade, in contrast to great variability among the smaller, the largest show constancy of numbers and distribution. Dorsally the setae of each segment form an irregular row, the smaller ones scattered amongst the largest, while ventrally they tend to be arranged in two rows, the largest in a posterior row which has no interspersed smaller setae. Thus a formula may express the numbers of these largest setae on tergum and sternum; for segments 1-6 inclusive, in *H. spiniger* and *H. ualabati*, it is:— (dorsal/ventral) 4/4, 6/6, 6/6, 6/8, 6/8, 6/8.

Terminalia. (Plate V, figs. B-H; Plate VI, figs. A, B). The terminalia in *H. spiniger* and *H. ualabati* are of the same general type, and consist of the modified terminal segments of the abdomen in male and female, and of the external genitalia in the male. Terminology is that used by Snodgrass (1935).

The terminal abdominal segments in male and female have their tergal and sternal plates modified as copulatory processes by the development of a row of stout setae ('sr') along the posterior border of the sclerite (Plate V, figs. B-D). It is probable that these setae help to hold the individuals in copulation, the two series becoming interlocked. This row of setae occurs on the tergum in the ♂ and on the sternum in the ♀, and so it is to be expected that the ♀ rides on the ♂ during copulation (c.f. Werneck (1936), pl. 1).

In *H. spiniger* and *H. ualabati*, the external genitalia of the ♂ (Plate V, figs. E-H; Plate VI, figs. A, B) consist of an apodemal plate and a phallus. The apodemal plate (Plate V, fig. E, 'ap') has upraised sides posteriorly; to these sides are hinged the parameres (Plate V, fig. E, 'pm'), and posterodorsally, a flap (Plate V, fig. E, 'f'). Near the hinge points of the flap arise a pair of lightly-chitinized bars (Plate VI, fig. A, 'b'), so that the base of the phallus is supported by the bars and the apodemal plate ventrally and by the flap dorsally. The flap does not appear to be hinged directly to the apodemal plate, but indirectly via a pair of rods shaped like blunt thorns, which are hinged in turn to the apodemal plate, above the hinge points of the parameres.

The phallus is a thin-walled tube, bearing a series of processes and spines (Plate V, figs. E, 'ph'; F-H). In general its structure is the same in *H. spiniger* and *H. ualabati*, but there are differences of detail in the two species. Unfortunately, owing to lack of material, dissections were possible only for *H. spiniger*, so that the details of the phallus structure (particularly the central area) in *H. ualabati* were not followed as thoroughly as was hoped, Plate V, fig. H, being a diagrammatic reconstruction from the introvert phallus, based on the structure of the extrovert phallus in *H. spiniger*.

The phallus in *H. spiniger* (Plate V, figs. E-G; Plate VI, fig. B) may be divided into a lightly-chitinized basal region ('r' 1), a central region bearing various processes ('r' 2), and a lightly-chitinized terminal region ('r' 3). The basal region is a simple tube. The central region bears two prominent lateral processes ('lp'), and a ventral beak-like structure ('bk') having at its sides two small processes ('p'); there are no processes dorsally. The lateral processes bear distally on their outer edges heavily-chitinized concavities; they do not bear teeth. The lateral processes and the beak-like structure are strengthened by sclerotizations (Plate V, fig. G, 'sc' 1-'sc' 4). The terminal region of the phallus bears two rows of three spines ('st') and is covered, over most of its area, with small spinules; this character of the two rows of spines is a specific one in this species. The retracted phallus

has its processes lying within the tube, and, in situ, therefore shows inversion of the tube only; on eversion, the processes come to lie on the outer surface of the tube so formed.

The phallus in *H. ualabati* (Plate V, fig. H; Plate VI, fig. A) differs from that in *H. spiniger* as follows. The central region, of which the detailed structure was not determined, bears two prominent lateral processes ('lp' 1), which have their distal margins toothed. The terminal region of the phallus bears two sac-like structures ('ss') covered with spinules; no spines are to be found such as occur on this region in *H. spiniger*.

MEASUREMENTS AND COUNTS

In Table 1 is set out a summary of measurements and counts referring to *H. spiniger* and *H. ualabati*. The measurements were made with an ocular micrometer; This was calibrated against a stage micrometer and the absolute measurements interpolated after summarizing. The setal counts refer to the total number of setae occurring on the sclerite, except those made in connexion with the terminalia which refer only to a particular row of setae (Plate V, figs. B-D, 'sr'). Only mature males and females were considered. The selection of individuals for statistical analysis was qualitative, the criteria being the structure of the phallus for the male, and occurrence on non-marsupial hosts for females of *H. spiniger* (since only one type of male was found on such hosts; the results of the analyses support such selection). It must always be remembered that the measurements were made on specimens mounted on slides; such mounting results in some degree of distortion.

It is seen that while characters such as the number of setae sternal plate 1st thoracic segment, number of setae 1st tergite abdomen, are generic characters, significant differences exist for other characters. It is impossible to assess the value of such differences in the absence of material representing the genus as a whole, for until the whole has been examined the possibility that intermediate types may exist must always be kept in mind. Should difficulties arise when the whole genus has been surveyed, it may still be possible to characterize species by a group of measurements.

TABLE 1

	Number.	Mean.	Max.	Min.	S.D. (n-1).
<i>H. spiniger</i> : head width mm.	70 ♂ ♀	0.640	0.700	0.568	0.031
	29 ♂ ♂	0.638	0.700	0.581	0.031
	41 ♀ ♀	0.642	0.700	0.568	0.031
<i>H. ualabati</i> :	11 ♂ ♂	0.698	0.719	0.680	0.013
<i>H. spiniger</i> : head length mm.	70 ♂ ♀	0.423	0.462	0.383	0.021
	29 ♂ ♂	0.420	0.462	0.383	0.023
	41 ♀ ♀	0.426	0.462	0.383	0.020
<i>H. ualabati</i> :	11 ♂ ♂	0.480	0.502	0.462	0.019
<i>H. spiniger</i> : ratio: head width/head length (calculated from the separate values).	70 ♂ ♀	1.51	1.67	1.34	0.054
	29 ♂ ♂	1.52	1.60	1.43	0.042
	41 ♀ ♀	1.50	1.67	1.34	0.060
<i>H. ualabati</i> :	11 ♂ ♂	1.45	1.51	1.39	0.044
<i>H. spiniger</i> : setae sternite 1 thorax (n = 2 (x + y + z) + a).	71 ♂ ♀	17.96	23	13	2.24
	28 ♂ ♂	18.04	21	13	2.20
	43 ♀ ♀	17.91	23	14	2.26
<i>H. ualabati</i> :	11 ♂ ♂	18.55	21	16	1.29

	Number.	Mean.	Max.	Min.	S.D. (n-1).
<i>H. spiniger</i> : sternite 1 thorax, intersetal distance xx. mm.	25 ♂ ♀	0.156	0.181	0.133	0.012
	15 ♂ ♂	0.153	0.169	0.133	0.010
	10 ♀ ♀	0.160	0.181	0.145	0.013
<i>H. ualabati</i> :	5 ♂ ♂	0.194	0.207	0.183	0.010
	75 ♂ ♀	a 0.189 b 0.092 c 0.087	0.215 0.106 0.106	0.188 0.079 0.068	0.010 0.007 0.009
<i>H. spiniger</i> : sternite 3 thorax, intersetal distances mm.	32 ♂ ♂	a 0.188 b 0.093 c 0.086	0.208 0.105 0.106	0.168 0.081 0.068	0.011 0.007 0.010
	43 ♀ ♀	a 0.191 b 0.092 c 0.087	0.215 0.106 0.103	0.174 0.079 0.071	0.010 0.007 0.003
<i>H. ualabati</i> :	7 ♂ ♂	a 0.224 b 0.109 c 0.121	0.242 0.118 0.134	0.211 0.100 0.108	0.012 0.007 0.010
<i>H. spiniger</i> : setae tergite 1 abdomen (n = 4 + a).	66 ♂ ♀	17.11	21	13	1.75
	27 ♂ ♂	16.74	19	13	1.51
	39 ♀ ♀	17.36	21	13	1.89
<i>H. ualabati</i> :	9 ♂ ♂	15.67	19	14	1.73
<i>H. spiniger</i> : setae tergite 8 abdomen ♂	30 ♂ ♂	Left 6.40 Right 6.23 Total 12.63	8 8 15	5 5 10	0.98 0.82 1.54
<i>H. ualabati</i> :	Total: Counts (latter four doubtful), 19, 22, 23, 23, (20, 20, 25, 25). Approx. mean 22.				
<i>H. spiniger</i> : setae sternite 8 abdomen ♀	39 ♀ ♀	Left 8.95 Right 8.82 Total 17.77	11 11 21	7 7 14	1.05 0.97 1.75

SEX RATIO

A summary of data for specimens of *H. spiniger* infesting the dog shows a general preponderance of females over males. The only total count ('Dog', Canal Zone: 96 ♂ ♂, 122 ♀ ♀) gives a sex ratio of 79 ♂ ♂ to 100 ♀ ♀. However, in view of the findings of Buxton (1937) these results have little or no significance.

NOTES

The genus *Heterodoxus* was defined by Le Souëf and Bullen (1902) for an amblycerous parasite of 'Kangaroos, Wallabies, &c.', *H. macropus*, which they described. Johnston and Harrison (1913) and Harrison and Johnston (1916) re-examined Le Souëf and Bullen's material and concluded that, in view of the wide range of variation found, *H. macropus* was identical with Piaget's *Menopon longitarsus*, also assigning to the species specimens from several macropods and from dogs. They direct attention, however, to the chaetotaxy of the thoracic sternites and to the genitalia.

Specimens examined include many of those upon which previous records have been based, and much of the Harrison and the Le Souëf and Bullen collections. Unfortunately, no material was available from several of the species listed by Harrison and Johnston (1916) as hosts of '*H. longitarsus*'. Material in the Le Souëf and Bullen collection labelled '*Heterodoxus macropus*' comprised more than one species, so that the status of *H. macropus* could not be determined definitely and the species must be ranked as a synonym of *H. longitarsus* (Piaget). Mr. A. S. Le Souëf informs me that no specimens of *H. macropus* were designated types. Froggatt (1907) labels his figure as 'drawn from the type', but this will be a mistake.

DISCUSSION

The genus shows great constancy in the series examined; this, with the great individual variation, makes species diagnosis difficult. The parasites from a host individual tend to group together and to show some constancy; the body proportions, the number of setae on a particular sclerite, in a series from one host individual may differ markedly in that from another, but this definiteness is not apparent when the several series are considered together. Certain characters show much greater individual variation than others, and belong to the group as a whole rather than to the species.

A classification based on morphology alone is not possible for both sexes, for while the structure of the phallus permits species differentiation in the male, there is no one other character of absolute diagnostic value. This means that the female may be associated definitely with the male only after: (1) examination of long series of individuals, collected from known hosts, with special attention paid to the possibility of regional distribution on the host's body; (2) mating and breeding experiments (association of the sexes of *H. spiniger* is possible because of the abnormal host relations shown by this parasite). Although it may be found possible to delimit species by a series of characters considered together, and the findings for *H. spiniger* would indicate this, at present the number of individuals available for examination is so small that no attempt is warranted.

In elaborating a scheme of classification in the genus it would seem that attention should be paid to the following points:—(1) the structure of the phallus in the male, (2) arrangement of setae on the terminal abdominal segments, (3) arrangement of setae on the metathoracic tergite and sternite, the abdominal sternites and, doubtfully, the prothoracic sternite, (4) measurements for head and thorax, of which those considered here might form a basis. It may be argued that environment may influence the distribution of setae on the ventral surface, but this does not seem to hold since: (a) the tergal chaetotaxy of the metathorax and that of the terminal abdominal segment in the male, appear to have a specific value, (b) all specimens from non-marsupial hosts have the same chaetotaxy as well as phallus structure, and it seems reasonable to suppose that the environments offered are various, (c) a series from an individual *Wallabia bicolor* comprised two species on phallus structure, although the possibility of each being confined to a definite region of the body must be remembered.

To summarize, the investigation has done little but present a number of problems for future study and *until very much longer series, from all hosts, have been examined critically, the issue must remain indefinite*. Are the species here outlined but variants of the one natural group, the limits of which have yet to be defined, that is, but one species, 'a population the members of which form a genetically interlinked complex' (Ferris, 1935)? Or are we dealing with a case of convergence? The internal anatomy of the various forms has not been studied. Of 79 specimens from various marsupials (Macropodidae) I can assign only two males to the same group as those examined from non-marsupial hosts, *which all belong to the same group*, a fact which emphasizes our ignorance of the physiology of host specificity. No experimental infections and cross-infections were carried out. Finally, it is of interest that *Heterodoxus* has not been recorded from the Australian Dingo (*Canis dingo* Meyer), though admittedly there are but two records of ectoparasite examinations of this host, a *Trichodectes* being found in each case; I have seen a series of lice from a dingo and they were also a species of *Trichodectes*. Does *Heterodoxus* occur on the dingo; if not, why not? Mr. A. Arnold informs me that his trappers report ectoparasite infection of the dingo to be of rare occurrence in West Australia.

Ferris (1930) has recorded six parasite species from a single host individual. In the material examined by me four species of *Heterodoxus* (based on phallus structure) have *Wallabia bicolor* as host, a series from one host individual containing two species of *Heterodoxus*. It is to be emphasized, however, that some of the parasites were from animals in zoological gardens; moreover, a species may be confined to some region of the host's body, and hybridization may be possible.

Although it is not possible to assess much of the literature relating to *Heterodoxus*, records from non-marsupial hosts can all be assigned to *H. spiniger* with some degree of certainty.

I should like especially to thank Professor E. J. G. Pitman for his help with the statistical analyses. To Professor W. S. Patton I am indebted for helpful criticism.

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PLATE III

THE HEAD. A-J, *H. spiniger*. K, *H. ualabati*. A, ♀ from dog, Java, 'aa' head width, 'bb' head length. B, ♀ from dog, Brasil. C, ♂ from dog, Belgian Congo. D, ♂ from *Oncifelis salinarum*, Argentina. E, ♂ from dog, California; type *H. armiferus* Paine. F, ♀ from dog, California; type *H. armiferus* Paine. G, ♂ from coyote, California. H, ♀ from *Oncifelis salinarum*, Argentina. I, ♀ from dog, South Africa; type *M. spiniger* Enderlein. J, ♀ from jackal, Uganda. K, ♂ from "Black Wallaby", Victoria; type *H. macropus* Paine. Convention all figures: dorsal to left, ventral to right.

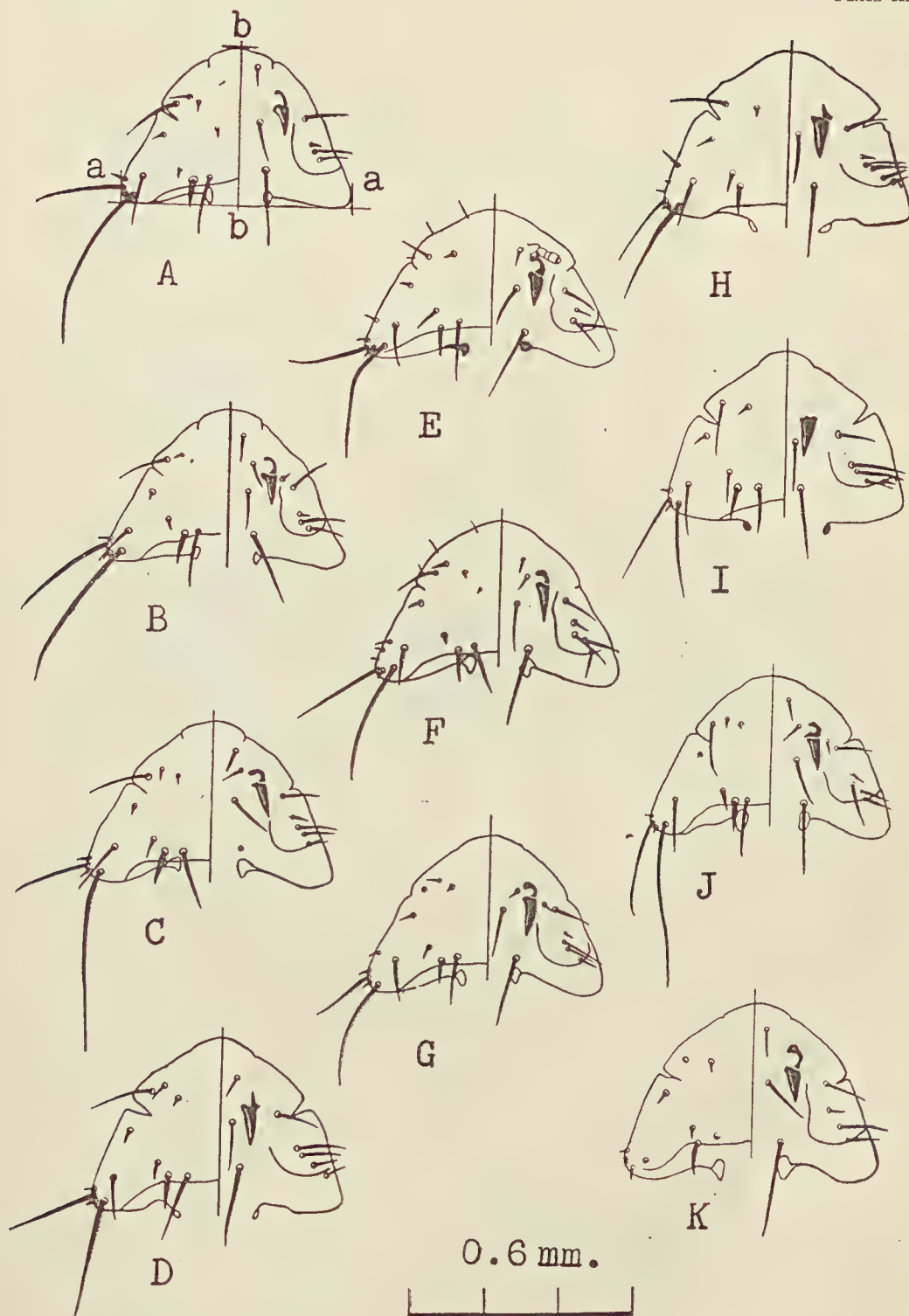


PLATE IV

THE THORAX. A, thorax from above, with first abdominal tergite, ♀ *H. spiniger*, dog, Java; 'so', sense organ first abdominal tergite. B, first thoracic tergite, ♂ *H. spiniger*, *Oncifelis salinarum*, Argentina. C, first thoracic tergite, ♂ *H. ualabati*, *Wallabia bicolor*. D, third thoracic tergite, ♂ *H. spiniger*, coyote, California. E, thorax from below, with first abdominal sternite, ♀ *H. spiniger*, dog, Java. F-H, plate first thoracic sternite, *H. spiniger*: F, ♀ from jackal, Uganda; 'x', 'y', 'z', three pairs generally occurring setae. G, ♀ from dog, Java; note seta 'x' duplicated on left. H, ♀ from dog, South Africa; type *M. spiniger* Enderlein. I-K, plate third thoracic sternite, *H. spiniger*; L, *H. ualabati*: I, ♀ from dog, South Africa; type *M. spiniger* Enderlein; intersetal distances 'a', 'b' (mean of 'b', 'b'1), 'c'; note extra pair of spines 'm', 'm'1, at sides of plate. J, ♂ from dog, Australia. K, ♀ from dog, Java; note extra spine 'n' on plate. L, ♂ from 'Black Wallaby', Victoria; type *H. macropus* Paine; note extra pair of spines 'o', 'o'1, on plate.

Scale: A-E, scale 'x'; F-L, scale 'y'.

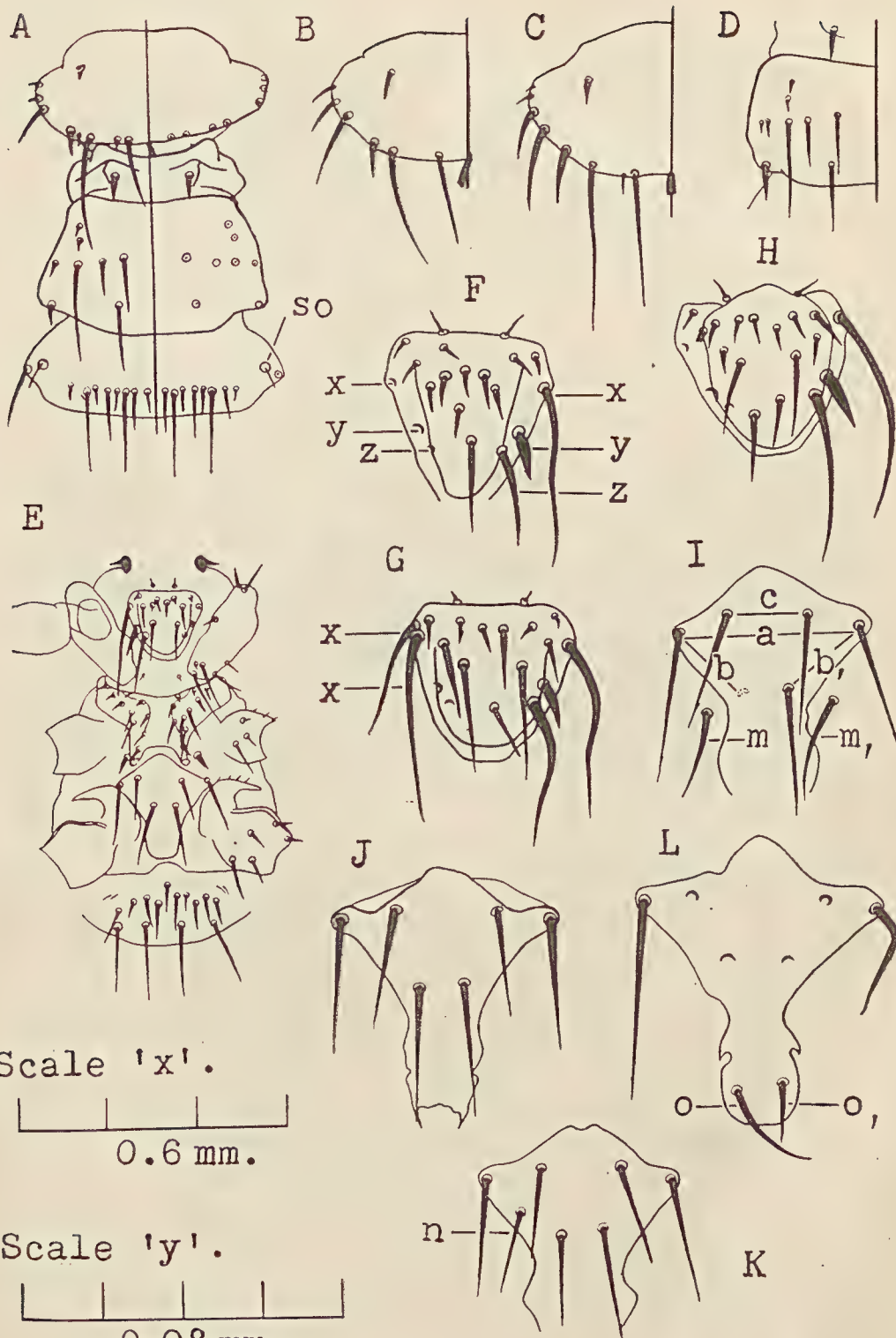


PLATE V

THE ABDOMEN. A, Abdomen, omitting detail of terminal segment, ♀ *H. spiniger*, dog, Brasil; setae other than largest represented by dots for sternites 4, 5; 'so', sense organ; 'sp', spiracle. B-D, terminal abdominal segments, showing setal row, 'sr'. B, ♂ *H. ualabati*. C, ♀ *H. spiniger*. D, ♂ *H. spiniger*. E, external genitalia, with extrovert phallus, ♂ *H. spiniger*. F, phallus, ♂ *H. spiniger*, diagrammatic relief. G, extrovert phallus, ♂ *H. spiniger*. H, extrovert phallus, ♂ *H. ualabati*.

E-H: 'ap', apodemal plate; 'bk', beaklike structure; 'f', flap; 'lp', 'lp1', lateral process; 'p', process; 'ph', phallus; 'pm', paramere; 'r1', 'r2', 'r3', basal, central and distal regions of phallus; 'sc1', 'sc2', sclerotisations strengthening lateral processes; 'sc3', 'sc4', sclerotisations strengthening beaklike structure; 'ss', saclike structure; 'st', spine.

Convention: A-D, dorsal to left, ventral to right; E, from the side; F-H, from below. Scale: A, scale 'x'; B-D, scale 'y'; E-H, not to scale.

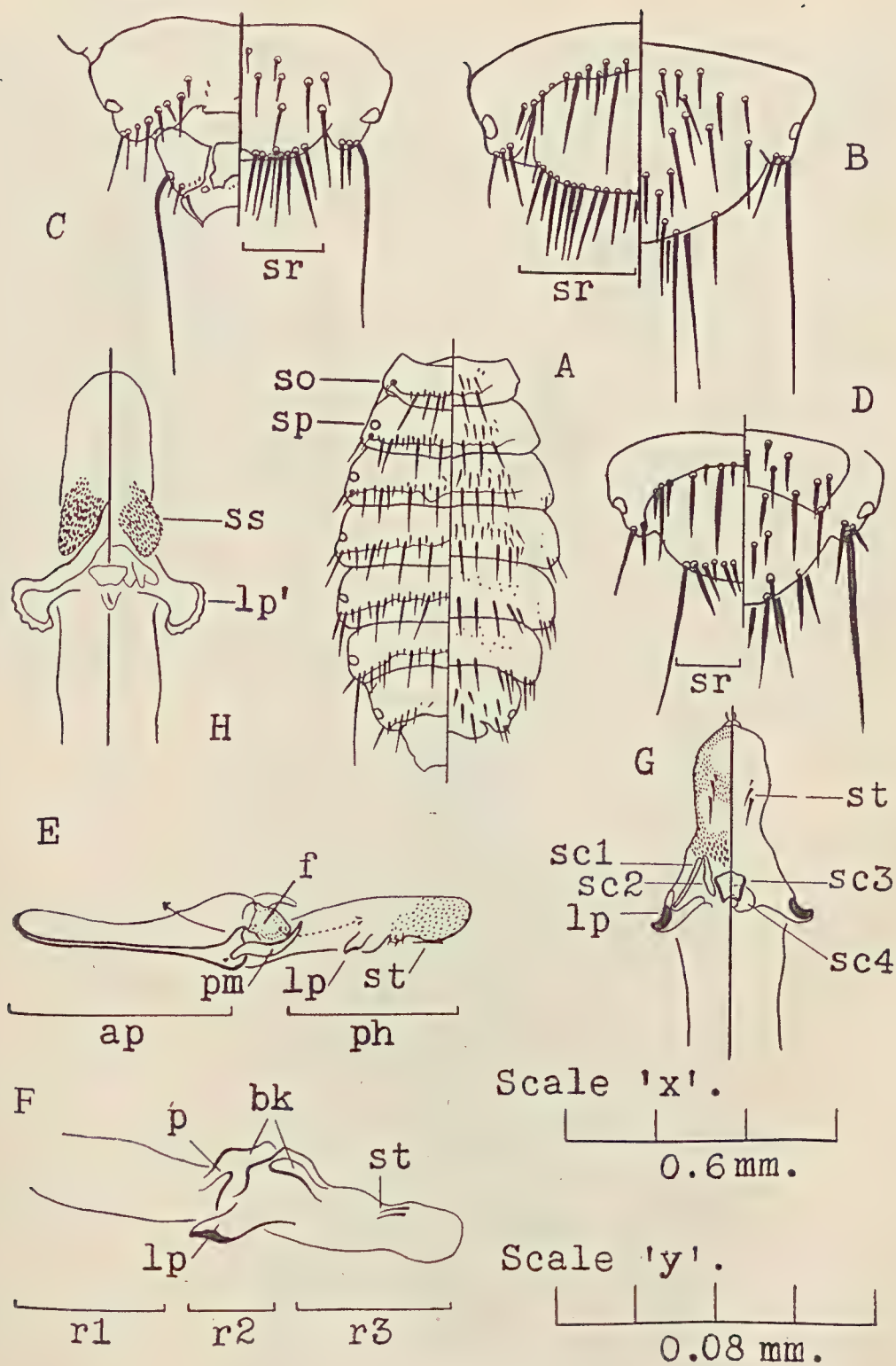
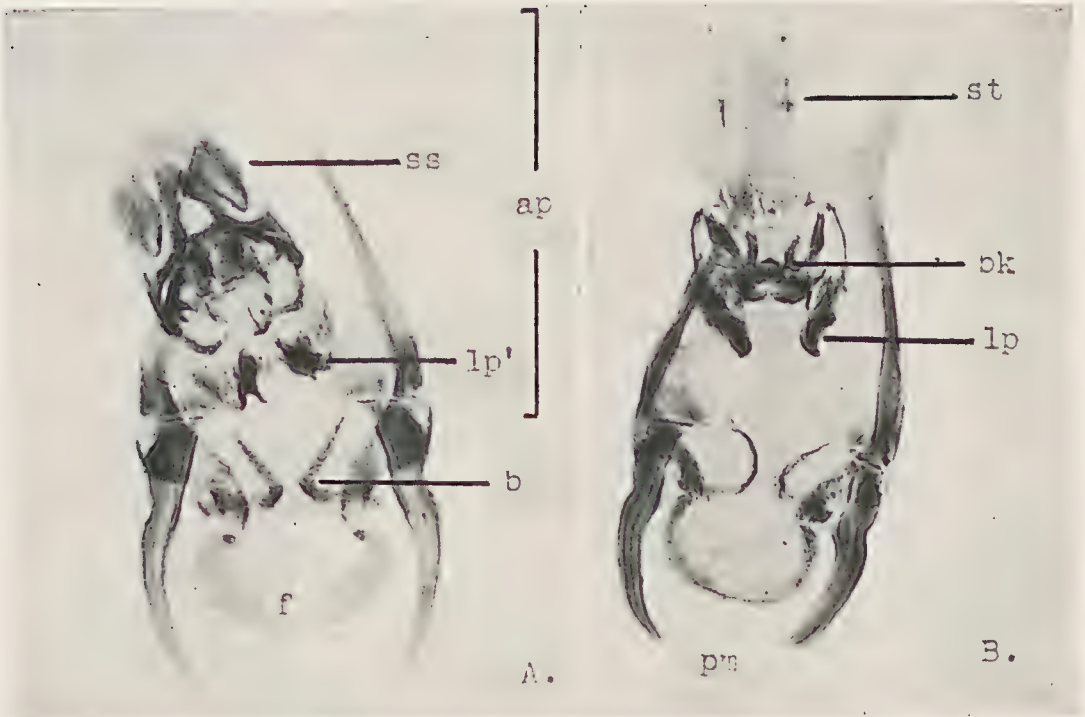


PLATE VI

A, external genitalia *H. ualabati*, in situ. B, external genitalia *H. spiniger*, in situ. C, *Heterodoxus spiniger* (Enderlein) from *Herpailarus salinarum* Thomas, (Argentine, Jujuy, F. L. Werneck.).
A, B: 'ap', apodemal plate; 'b', bar; 'bk', beaklike structure; 'f', flap; 'pm', paramere; 'lp', lateral process; 'ss', saclike structure; 'st', spine.



NATIONAL MUSEUM OF VICTORIA

The Distribution of *Heterodoxus spiniger* (Enderlein)

By

GORDON B. THOMPSON

(Read 13th November, 1939)

Plomley and Thompson (1937) drew attention to the interesting distribution of *Heterodoxus* on non-marsupial hosts; the present paper consists of the records of distribution and other information relating to the problem. In collecting this information, I have been helped by numerous workers; it would be quite impossible to list them all, but I wish to take this opportunity of thanking them all for their kind co-operation.

HOST SPECIFICITY

In view of the relationship of the parasite, there can be little doubt that the true hosts of *Heterodoxus spiniger* are Australian marsupials (kangaroos and wallabies); it may be possible to limit the host to a single species or group of very closely-allied species when more extensive collections are available. Host specificity is perhaps more definite in the Mallophaga than in any other group of ectoparasitic arthropods. A species is normally found to be a parasite only of a single host species or group of very closely allied host species. At present we know nothing of the factors controlling host-specificity, but considering the apparent opportunities for the transference of a parasite from one host to another, it is surprising that the establishment of a louse species on a host other than its 'phylogenetic' host does not occur more often. The occurrence and establishment of a parasite on such another host is a phenomenon to which the term *straggling* is applied.

The numerous records of the occurrence of *Heterodoxus spiniger* on the domestic dog show that it is a well-established parasite of this animal, but its haphazard geographical distribution emphasizes that it is a straggler. The records suggest that the straggling has occurred not in the distant past but recently, and that the parasite is becoming more firmly established and more common on its new host rather than waning. The louse does not seem to have been found on non-marsupial hosts until about 1900, while *Trichodectes canis* was described over a hundred years ago. There are no records of *T. canis* having been taken together with *Heterodoxus* off the same dog. I have, however, received specimens of the sucking louse *Linognathus setosus* (Olfers) and the flea *Ctenocephalides canis* (Curtis) taken in company with *H. spiniger* from a dog in Tasmania. It appears that in some parts of the world, e.g. South Africa, *H. spiniger* is the 'normal' parasite of dogs, while *T. canis* is unknown. The occurrence of *H. spiniger* on an ocelot, *Herpailurus salinarum* Thomas, in Argentina is difficult to explain (Werneck

(1936)). Dr. Werneck tells me that there was quite a flourishing colony of the parasite on the animal when it was killed. Its occurrence on the coyote and jackal may be due to the association of the domestic dog with these closely allied forms. Cummings (1913) has recorded *Heterodoxus* from a crow (*Corone australis* = *Corvus coronoides* V. & H.), but the record is probably one of chance straggling, when the bird settled on a dead marsupial or dog to feed.

NEW RECORDS

Plomley (1940) has recorded a number of instances of the finding of *Heterodoxus spiniger* on dogs. The following additional records refer to hitherto unpublished instances of the finding of *Heterodoxus* sp. on dogs.

N. California, 1937 (M. A. Stewart). California, Madera County, 5. iv. 1932 (W. L. Jellison). Oklahoma, Stillwater, 1925. Kansas, Manhattan, 10. ii. 1912 (J. W. Scott). Arizona, Phoenix, 1928. Venezuela, Zaraza, 1935. British Guiana, Georgetown, 27. x. 1922. Ecuador, 1930. Haiti, Momance, 1913. Burma, Rangoon, 1931. Uganda, Kampala, iii. 1932 (G. H. E. Hopkins). Natal, iii. 1917. Sierra Leone, 3. x. 1925. Union of South Africa, Pretoria (Dr. Rene du Toit).

The record from the Canal Zone is of particular interest as a complete count was made of the parasites. The host was a dog, and 96 ♂♂, 122 ♀♀ and 39 immature specimens were collected.

The following notes were sent by the collector of the Javanese specimens:—'*H. longitarsus* (Piaget) is a pest in some cases in Java. The dogs have large bald patches on their backs and the parasites make large bloody, purulent wounds¹ in which they live in large numbers. One can find blood in the parasite sometimes. I have often found such'. In another letter the same collector states:—'the dogs with *H. longitarsus* (Piaget) also possess ticks and fleas but no lice. I have collected twenty examples of the parasite from one dog, but I think there were hundreds in the wounds. It is not very pleasant to investigate such dogs.'

Dr. Stewart informs me that some dogs in northern California were recently found to be very heavily infested with *Heterodoxus*. He believes, in the absence of definite data, that this louse is rather common on domestic dogs in northern California. Dr. R. du Toit informs me that *Heterodoxus* is a very common parasite of dogs throughout South Africa.

Until recently the only record of the parasite from India was based on specimens in the Indian Museum collected from domestic dogs in Calcutta and labelled as "*Menopon spiniger*". Additional specimens taken from a dog in Calcutta have recently been received.

On the authority of the Department of Agriculture of the Philippine Islands at Manila, the parasite is unknown in the islands. In the United States National Museum, however, there is a single specimen collected from a man, Phillipine Is., Victorias Oc. Negros, 1930. This record makes the second instance of the occurrence of *Heterodoxus* on man. I think on the evidence of the single specimens recorded in each case that the occurrence of this parasite on man may be regarded as accidental; the close association of man with the dog must always be remembered.

¹ According to this collector, numerous ticks (*Amblyomma* sp.) were found on the dogs in company with the lice and it must be borne in mind that the lice may have taken up their positions at points where ticks had previously attached themselves.

ABSENCE OF THE PARASITE FROM VARIOUS PARTS OF THE WORLD

In the course of collecting together the distributional data of this parasite, certain workers were kind enough to supply definite evidence of its absence. As these are of interest the areas are listed below, together with the correspondents' comments.

Mauritius, Ceylon, New Zealand, Fiji Islands, Trinidad, Jamaica (1), Gold Coast (2), Nigeria (3), British Somaliland (4), Canada, Europe, U.S.S.R., Cyprus, China (Shantung), Iran.

- (1) 'I have never found any lice on dogs in Jamaica. The dog in Jamaica has probably been protected by the prohibition against their importation from all countries except the British Isles. This regulation has been in force for 30-35 years.'
- (2) 'No lice have ever been found on dogs in the Gold Coast.'
- (3) 'No lice seen on dogs during fifteen years in Nigeria.'
- (4) '. in this Mohamedan country there are virtually no dogs except a few European owned animals and I have not so far encountered lice on dogs here.'

In Ceylon, Fiji Islands, and Canada only *T. canis* has been observed; I have recently seen specimens of this louse taken from a dog in New Britain; Kieta District, 16. x. 1937. There is reliable evidence that *T. canis* does not occur in the remainder of the regions listed above.



Map to show records of distribution of *Heterodoxus* on the dog, together with those of distribution on *Herpailurus salinarum*, coyote and jackal. Records from all sources.

GEOGRAPHICAL DISTRIBUTION OF THE PARASITE

On the accompanying map of the world, I have indicated the places from which *Heterodoxus* (almost certainly *H. spiniger* in all instances) has now been reported from non-marsupial hosts, and it is interesting that all the localities are within the area confined between lat. 40°N. and lat. 40°S., or very nearly.

The distribution of a louse is normally controlled by its host but it appears that the controlling factor in the present case may be climatic. If this distribution is as real as it appears from the records to date, it may throw some light on a feature of parasitism concerning which we know very little. It may be that as a result of the parasite having adapted itself to a new and 'non-phylogenetic' host, other factors have come into force. Van Volkenberg (1936) suggests climatic factors to explain the absence from Porto Rico of certain parasites of imported hosts (domestic animals).

TRANSFER TO NEW HOSTS

How this biting louse became a parasite of the domestic dog, is difficult to say. Three possibilities present themselves. First, since the true hosts (i.e. kangaroos and wallabies) of this louse are, I understand, fairly easy animals to keep in zoological gardens, the parasite may have become transferred to dogs as a result of contact with these marsupials, in the various part of the world to which they have been transported (Ewing (1933)). Yet, zoological gardens are very much more common in those regions where the parasite has not yet been recorded!

Secondly, in the past when settlers arrived in Australia with their dogs, the marsupial hosts were much more common than they are to-day, and the dogs may have acquired the lice from hunted marsupials; having established itself on dogs in Australia it became distributed by the dogs when accompanying man on his voyages to other parts of the world. Yet, the parasite does not seem to be common on non-marsupial hosts in Australia, and moreover, few dogs, if any, are exported from Australia!

Thirdly, it is common for ships to carry pet dogs and equally so for ships visiting a foreign port to take away with them some animal peculiar to the country visited; many ships visiting Australia would take away with them a kangaroo or wallaby, these animals being probably the most readily obtainable 'curiosity', and a very well-known one outside Australia. Here then is a possible link between the dog and the marsupial, and it is noteworthy that the parasite has been reported from most of the important seaports between the parallels of 40°N. latitude and 40°S. latitude.

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Geology of the Tyenna Valley

By

A. N. LEWIS, LL.D.

(Read 13th November, 1939)

PLATES VII-X

The field work which has resulted in the collection of the data here set out was undertaken in the first place in an endeavour to find a definite floor of the permian sedimentary sequence in order to measure the vertical succession, a search which has now been prosecuted by the writer over the whole island, without success. In the course of this investigation some remains of trilobites were found in rocks previously mapped as permo-carboniferous. This find rendered desirable a further investigation into the stratigraphical position and relationship of these beds and has lead to the discoveries here recorded.

The Tyenna Valley is the area with the easiest access from Hobart where lower palaeozoic rocks outcrop and is a junction area between the dolerite capped plateaux of the centre and south-east and the older rocks of the western mining fields. Such areas are vital to the interpretation of the sequence of geological events in Tasmania and the one here described is the most readily accessible of such areas. Further, the neighbouring areas of Adamsfield to the west, the Mt. Anne and the Weld River Valley to the south-west, Mt. Field Plateau to the east and the Florentine Valley to the north have already been the subject of more or less detailed geological investigation. The district described here abuts on those areas and provides an essential connection without which the accounts already published are deficient in scope.

The field work was carried out during the Christmas holidays of 1937 and 1938 and the Easter holidays of 1938 with several day trips to the trilobite beds at Juneec.

The writer was accompanied on the first two trips by Mr. B. Koch and on the last by Mr. W. A. Tate. He was also accompanied to the trilobite beds by Dr. F. W. Whitehouse. He desires to express his appreciation of the assistance rendered by these gentlemen. He also records with thanks the assistance given by Mr. J. F. N. Murray in the drafting of the plans and sections accompanying this report.

PREVIOUS LITERATURE AND HISTORY

Thirty years ago W. H. Twelvetrees (1908, 1909), Government Geologist, published two very brief accounts of this area, with sketch maps. These were

compiled for the special purpose of enabling the government of the day to consider the extent of the concessions being asked by the Great Western Railway Company. Although still valuable and of great use, many of Twelvetrees' conclusions must now be revised in the light of more recent field work.

T. Stephens (1910) contributed a brief paper to the Royal Society of Tasmania describing certain features near Glenora, but this is of little use today beyond a record of actual field observations along a limited line.

A. McIntosh Reid (1921), a former Government Geologist, mentions this area briefly in his *Osmiridium* in Tasmania. His map (*ibid.* Plate X) is valuable and as far as it goes is much in advance of Twelvetrees' sketch but the scope of Reid's work limited the text to a very general reference to the area discussed in this paper.

In 1902 T. Stephens discovered some trilobite remains on the flanks of Tim Shea in the Florentine Valley. Unfortunately, he did not himself describe the locality or stratigraphic relationships of his find which have, until now, remained a mystery to Tasmanian geologists. The palaeontological significance of this find was recorded by R. Etheridge Jun. (1904).

The adjoining areas have been surveyed or briefly described:—

In 1921 Loftus Hills reported on the geology of a small section of the Florentine Valley from the point of view of its suitability for water conservation and dam sites. His report has not been published but is available for inspection at the Mines Office, Hobart. The area covered by Hills abuts to the north on the district dealt with in this account but many of Hills' conclusions as to the geological structure of the country towards Junee—i.e. south of the area on which he was reporting must be revised in the light of fuller investigation.

In 1922-1923 the present writer described the topography of the upper levels of the Mt. Field Plateau which lies to the east and north of the area here described. In 1924 a further paper was published comprising a general description of the Mt. Anne district, Weld River Valley and southern slopes of Mt. Mueller. This area lies to the south-west of the area here described and abuts on to it.

P. B. Nye (1929) contributed a very comprehensive account of the Adamsfield District to the north-west of the area here described with an excellent map. This account is the most detailed survey of any area in South Western Tasmania yet published.

Reference need only be made to Mr. Nye's Bulletin on the Adamsfield District (1929, pp. 2-4) for an account of the history of mining in the district. Access to the area described by Nye was through the district here described. During a lengthy period extending from 1885, or thereabouts, to 1909, the Tyenna Valley was thoroughly investigated by prospectors many of whose workings are still discernable in the regrowth forests.

The following changes in Twelvetrees' place names may here be noted to avoid confusion:

'Roll's Selection' is now Junee township.

'Rumney's Selection' is now owned by Jeffreys.

'Lord's Selection' is now known as Maynes', the name of a former owner, but it has recently been acquired by the Kallista Timber Development Co. Pty. Ltd. Kallista mill, now burnt out, stood on the eastern boundary of Mayne's farm and the Kallista Railway station is located a little west of Rumney's Selection (now Jeffrey's).

The township of Tyenna has dwindled in importance and Fitzgerald, some two miles further west, with the contiguous township of Juneë, have become the more important centre in the valley. With these exceptions Twelvetreë's place names still stand. The Adamsfield pack track follows, with a few deviations, the Great Western Railway pack track as sketched by Twelvetreë's.

'High Rocky' of Twelvetreë's is called by its official name, Mt. Mueller in this account. The name 'Mt. Stephens', is replaced, in accordance with universal usage by 'Tim Shea'. The former name was not bestowed in honour of the late Mr. Thomas Stephens in which case it should have been retained, but dates from a far earlier period.

'Mt. Humboldt' was changed to Mt. Field West in 1918. Humboldt, a name bestowed in honour of a famous scientist, by Strzelecki should now be restored. It has been so restored here and the name 'Mt. Field' used for Mt. Field East.

The names 'Tyenna Valley' and 'Tyenna River' are used in place of 'Russell Falls River'. Both names are in accordance with official cartography but Russell Falls River is an unfortunate choice as it does not flow over Russell Falls and we have a Russell River (a tributary of the Huon, rising in the vicinity) and a Russell Falls Creek.

GEOGRAPHY AND PHYSIOGRAPHY

The area here described comprises the Tyenna valley from its source on Mt. Mueller and neighbouring ranges to its confluence with the Derwent and extends to the divide between the Tyenna River and the Florentine River constituted by Mt. Mueller, The Needles, Tim Shea, Wherretts Look-Out and the Mt. Humboldt-Tyenna Peak Range, together with a brief description of the northern and north western slopes of that divide and portion of the Florentine Valley sufficient to connect it with the area described by Nye in his bulletin on the Adamsfield district. This area has a total length from east to west of about 25 miles and from north to south of about 10 miles.

The district is reached by rail and a first class road from Hobart via the Derwent Valley. Fitzgerald is some 54 miles distant from Hobart by road and rail. From Fitzgerald a good motor road extends to Juneë and thence a fair road has been constructed westward to Kallista (4 miles) and another good road north-westward across the Tyenna and Juneë Rivers to Storey's farm 3 miles west of Juneë. From Kallista a rough road, passable with difficulty by cars, extends to Maynes (2 miles). Thence the Port Davey track, now in an almost impassable condition, extends through the area to the south of Mt. Mueller. From Storey's a first class pack track extends through the area to Adamsfield via Tim Shea-Wherretts Look Out saddle and the upper Florentine bridge. In recent years the Forestry Department has cut numerous tracks through the forest. These, at present, give several lines of access to the Styx valley and to the Needles-Tim Shea ridges. The old Mt. Humboldt Mine track from Kallista to the Needles-Tim Shea saddle is still passable on foot with some difficulty. In general, the area has been well opened up since Twelvetreë's reported on it and although still mostly covered with dense rain forest, access is possible, although often with difficulty, to any part.

The country covered by this account is the wide forest-covered basin which lies at the head of the Tyenna Valley with its bounding ridges. This area is bounded on the north by the Mt. Field Plateau, particularly that portion known as Tyenna Peak, Mt. Mawson and Mt. Field East (Lewis, 1922) and to the west

by Mt. Mueller (Lewis, 1924). These two mountain masses are joined by a long ridge varying in elevation from 1900 feet to 3500 feet and formed by Wherretts Look-out, Tim Shea and the Needles. To the south, the area is bounded by the Maydena Range, which runs eastward from Mt. Mueller at an average elevation of 2000 feet and forms a rocky divide between the Tyenna Valley, and the Styx valley. To the eastward the area slopes gradually to the Derwent at Glenora. The head of the valley is a broad expanse of rain-forest covering numerous mountain spurs but of relatively open topography, some 10 miles across both from north to south and east to west, with a few steep-sided minor hills rising from the lower levels at 1000 feet to an average height of 1500 feet, and a ring of steep mountain slopes around the circumference rising to 4000 feet and over, in places. Further east, between Fitzgerald and Westerway, the valley becomes a gorge with steep and rocky, although forest covered, sides between the spurs of Mt. Field to the north and Marriott's Look-out at the end of the Maydena Range to the south.

Looked at from the purely topographical point of view, the area is a normal valley drained by a river originating in many small tributaries which rise in a semi-circle of high mountains and, after collecting these streams into one channel, flowing through a gorge to join the main river, the Derwent. Looked at from a purely geological point of view the area consists of normal permian-triassic sedimentary rocks with intrusive dolerite towards the east and west and in the higher altitudes and with a block of ordovician sedimentary rocks occupying the central or more open portion. When, however, the present physiography is considered in relation to the geological structure and history a surprising succession of contrasts is presented which force us to certain conclusions with a very definite bearing on the general structural framework of southern Tasmania.

GEOLOGY

This area shows a range of rocks within a few miles which in itself makes the locality of particular interest. The most extensive group of rocks represented is of ordovician age, perhaps with an upper cambrian base, and consisting of slates, quartzite-conglomerates, mudstones and limestones. This group is well represented in the central portion of the area. It is also possible that some of the devonian intrusive basic rocks or serpentines are to be found. The later lower palaeozoic series from the West Coast Range conglomerate series upwards to the various series assigned to the silurian period have not yet been identified although they occur further west at Adamsfield (Nye, 1929). A second important sedimentary group, extending from the permian tillite to the upper coal measures of triassic age with its intrusive dolerite is very completely represented both in the eastern and the western portion of the area. Pleistocene glacial deposits occur at higher altitudes and pleistocene to recent river deposits at the lower levels with late tertiary basalt in the extreme east of the area.

Structural Geology

It will be useful to describe area by localities before attempting to give any general summary of the geology as a whole. The area can be naturally divided into a number of major blocks as under.

A. Glenora-Westerway

The Derwent flows down a valley which is primarily due to faulting movements in pliocene-pleistocene times. It is marked by long parallel fault lines running roughly north and south, parallel to the general course of the river but crossed

repeatedly by the actual bed in its many bends. At Glenora, the Derwent with its tributary, the Tyenna River flows over a depressed block the eastern boundary of which is probably the fault running from the east coast of Bruny along the slopes of Mt. Wellington, Mt. Faulkner, Mt. Dromedary and Platform Peak. This block appears to have been slightly tilted to the westward, with permian limestones which appear at the fault line mentioned above in the Broadmarsh-Pelham Valley forming the eastern boundary of the block. The dip of the block brings the higher Ross sandstones and triassic coal measures down to the river level (100 feet above sea level) at the western edge of the block, the eastern boundary of the area described in this paper. Another major fault runs approximately parallel to the first mentioned fault and, subject to erosion details, forms the western boundary of the present Derwent Valley. This fault brings harder permian mudstones into sharp juxtaposition with the soft triassic coal measures and the Derwent has eroded its valley in the latter near the junction. It is flowing, in general terms, at right angles to the dip of the block of softer rocks and has edged over to the lowest point of the tilted block until its further erosion westward was impeded by the harder rocks west of the fault, although the still more resistant dolerite intruding the softer Ross sandstones and coal measures and also the more recent basalt flows have diverted the actual river course to a minor degree in many places and have been the final control regulating the actual course of the river as now seen.

The fault which brings the permian mudstone to the level of the triassic sandstone, is, as so usual in this country, rather a zone of converging faults than a clean break. This zone extends for some six miles in the valley of the Tyenna river. It is described by Stephens (1910, p. 172) although the significance of these features was not recognised at the time he wrote. From an analogy with similar fan-fault zones near Hobart, I postulate that the north-south fault meets one running roughly east-west along or parallel to the Tyenna valley in this vicinity. The north-south fault which may be termed the Ellendale fault constitutes the eastern boundary of the Mt. Field Plateau. It runs between Mt. Fenton and the lower spurs of the Mt. Field East, somewhat to the west of Fentonbury and Ellendale, and crosses the road to Dunrobin Bridge on the hill to the north of Ellendale. A minor fault forms the eastern edge of the disturbed area crossing the Tyenna valley a couple of miles east of Westerway and brings permian mudstone into juxtaposition with dolerite intrusive into Ross sandstone which form the rock of the Derwent Valley further east.

B. National Park-Fitzgerald

From about a mile east of National Park township westwards to Junee a normal sequence of upper permian-lower triassic rocks is to be seen somewhat broken by minor faults. In this distance the level of the river bed rises from 500 feet to 900 feet above the sea level. The strata have a slight dip to the westward (up stream). The base of the Ross sandstone appears at approximately the 900-foot contour. This is considerably lower than is usual and indicates the possibility of one or more small step faults parallel to the Tyenna Valley.

Between Fitzgerald and Junee, Ross sandstone occupies the bottom of the valley (approximately 900 feet) succeeding the permian mudstone without any marked unconformity. In this area a number of small faults at right angles to the main river valley are apparent in the road and railway cuttings but these are not of sufficient magnitude to replace the triassic strata by that of any other age. These faults, or some of them, appear to be responsible for the main topographical features of the Mt. Field Plateau already described (Lewis, 1922)

and of the Maydena Range to the south. The Maydena Range corresponds stratigraphically approximately with the Mt. Field Plateau but appears to have a much thinner cap of dolerite, which in at least one saddle south-east of Fitzgerald, is missing altogether, Ross sandstone extending to the summit of the range.

Between National Park township and Westerway the Russell Falls River flows across a bar of dolerite some 3 miles wide. It has cut through this to a depth of several hundred feet and is still cutting. This has resulted in the formation of a steep sided gorge which also constitutes a physiographic control for the higher reaches of the river, present erosion depending on the rate which the river is able to cut through the dolerite here. Above this gorge the valley is more open. The dolerite here appears to be at least 1000 feet in thickness.

A crushed zone is apparent in the permian mudstone of the valley floor on both sides of National Park township. Just west of the township the dip of the strata is 20° to the south-west. North of the river at the Park entrance the dip is $1-2^{\circ}$ to north. About $\frac{1}{2}$ mile east of National Park railway station the varying tilt clearly indicates the fault zone—the dip within 200 yards is 10° to south-west, 75° to north-west and 10° to south-east. In fact, this area is really a broken pressure fold. A major east-west fault along the present course of the river is apparent with slight over-thrusting from the south east. A north-south fault running just east of Russell Falls is also indicated.

The fault which is responsible for the Lake Fenton-Broad River valleys (Lewis, 1922) is apparent in the valley at Arcadia and a further fault, responsible for the Lake Belton-Belcher and Lake Hayes valley can be seen crossing the bottom of the valley about one mile west of Fitzgerald railway station whence it runs up the considerable valley of the Humboldt Rivulet entering the Tyenna River from the north. This fault is continued southwards up a corresponding but smaller re-entrant on the Maydena Range. These faults have only a small throw, difficult to measure owing to the absence of any identifiable key strata but the writer estimates the average throw at 200-500 feet.

C. Junee

Junee is the site, in the valley bottom, of the junction between lower and upper palaeozoic rocks. Unfortunately, the two great groups of rocks are, in every place where an inspection is possible, faulted against each other and no vertical succession is available for study.

Upper permian mudstone outcrops in the river bed at Fitzgerald railway station. Fifty feet or so higher up the valley side, it is succeeded by Ross sandstone which reaches the river bed, in the natural course of the prevailing slight westerly dip, about half a mile west of Fitzgerald although the actual junction in the river is obscured by recent alluvium. A major tectonic fault running approximately north and south cuts the valley near Junee railway station. This break is also obscured by alluvium but it appears to run from the Humboldt rivulet valley north east of Junee, southward a few hundred yards east of the road through Junee township and the prolongation of this road southward up the slopes of the Maydena range. A second fault runs from the middle of Junee township south-westward, just touching the Fitzgerald-Kallista road where that road crosses the spur between Junee and Pillingers Creek. The first mentioned is here called the Junee fault and the second the Roberts fault. A third fault runs down the valley of the main branch of the Tyenna River. The last mentioned fault is the same feature which has already been mentioned at National Park and is the main factor governing the valley topography. It is probably really a complicated

fault zone with many ramifications but the main river appears to follow one very marked break near the centre of this zone.

East of the Junee fault, Ross sandstone occupies both sides of the valley to a considerable height—showing a thickness of, perhaps 1000 feet, although allowance must be made for small unidentified faults running parallel with the valley. West of the Junee fault on the north of the valley blue limestone of the Junee series outcrops. In the bottom of the valley white quartzite appears from below the limestone. About a mile south of the river beds of blue Junee limestone again appear on the west of the fault. Between this latter limestone and the Roberts fault and the Junee fault occurs a wedge of permo-carboniferous sandstone, here called the Roberts sandstone as it covers practically entirely the farm owned by Mr. George Roberts. The spur between the Roberts fault and the Tyenna River is occupied by contorted yellow mudstones of the Junee series in which trilobite remains have been found. This bed ends abruptly at the river where the main east-west fault line brings white quartzite to the surface. The Roberts sandstone only extends at most $\frac{1}{2}$ a mile south of the Junee—Kallista road where it abuts on Junee Limestone at 1450 feet. This limestone skirts the hills south of Mr. Roberts farm and appears in the valley of Pillinger Creek from the Junee fault to the Roberts fault. Here it is cut off by the Pillinger fault west of which white quartzite of the Pine Hill block stands from river level (1000 feet) to 1450 feet. A mile and a half further south the main uplift of the Maydena range brings Ross sandstone again to the surface and this rock with its overlying intrusive silt of dolerite occupies the flank of the range from about 1450 feet to the summit at about 2500 feet. North of the river, at the Junee bridge there is some blue limestone. A few hundred yards along the road to Junee Cave, the yellow mudstone of the Junee series outcrops from below the blue limestone indicating a small fault just west of the ridge which runs southward to Junee bridge. The limestone appears at Junee cave and Storeys at an elevation of about 150 feet above Junee bridge.

The Roberts sandstone is a peculiar rock unlike any of the permian sequence as yet seen by the writer. Its nearest affinity is the fossiliferous marine sandstone at the top of the Preolenna coal measures but this analogy must not be pushed too far. It consists for the most part of coarse friable sandstone of a deep yellow to reddish colour merging into grits. Some layers are highly fossiliferous, consisting largely of stenopera and spirifera casts with many avicula pectens but these fossil bands do not lose the gritty nature of the bulk of the section. Fossil layers are to be seen on the road to Mr. Roberts house a few yards south of the Junee-Kallista road where the latter crosses the saddle between Junee and Pillinger Creek. Between the 1250 feet-1300 feet contours there are carbonaceous bands with numerous impressions of plant stems and it is possible that a search would reveal some small coal seams. Above 1400 feet the sandstones closely resemble the coarse members of the Ross series. These rocks extend to the southern extension of the road through Junee and masses of permian fossils are there found at 1250 feet. The red soil mentioned by Twelvetrees as occurring in this vicinity and considered by him to be evidence of basalt is the result of the decomposition of this sandstone. No basalt could be found.

This wedge of permian rocks abuts to the south and west on Junee limestone and is cut off to the east by the Junee fault. Its occurrence is a complete anomaly. It is a rock which does not exactly correspond with any in the southern Tasmanian permian sequence nor with exposures on the flanks of Mt. Mueller further west. Two explanations are possible. This sandstone may be a permian stage lower

than any hitherto observed and faulted into its present position by pressure induced by the earth movements which resulted in the Junee and other faults. If this were the case, it is strange that it is not exposed elsewhere. The lowest members of the permian sequence observable elsewhere in the area are barren slaty grey mudstones. The other alternative is that this is a bed corresponding more or less with the Cygnet and Preolenna coal measures which elsewhere has been removed from above the barren yellow mudstones of the Lindisfarne stage by erosion prior to the deposition of the Ross Sandstone, a possibility recognised by Mr. A. H. Voisey (1938). If this is true the rocks in question may have been protected by neighbouring hills of Junee limestone protruding through the sediments at the close of the permian depositions. This small section may thus prove an interesting factor in the correlation of the permian-triassic system.

On the railway from Junee to Kallista about a mile and a half west of Junee are two small cuttings in a yellowish mudstone—previously mapped by Twelvetrees and Reid as permo-carboniferous, quite understandable in the absence of good exposures prior to the construction of the Kallista railway extension. The more easterly of these cuttings is a perfect anticline, pitching at 30° to the north-west. The more westerly cutting is through a truncated anticline, only the easterly limb of which is exposed. This limb is dipping at 80° to the north-east. The strike of both anticlines is approximately parallel in a south easterly-north westerly direction. The rock here is a bed of relatively soft but tough mudstone, light yellow to buff in colour and closely resembling the uppermost permian mudstones in general appearance. The rock in the eastern cutting possess a silky, almost schistose or taley lustre in sections parallel to the bedding planes and is a mass of fossils, too imperfectly preserved for identification but either worm or shell tracks, coral or algae impressions or cephalopods, or probably, all three, with occasionally fragmentary pieces of trilobite in the more sandy layers and with one very soft sandy layer full of fragments of trilobites. The rock in the western cutting presents the features of a drag fold and a band of white quartzite with a further band of very hard ferruginous sandstone quartzite of dull reddish colour forming the extreme western layer of the series is obviously the resistant layer which has been dragged over and crumpled the softer mudstone of the core of the anticline. That mudstone is tough but very highly weathered and showing little metamorphic change. In fact, it is surprisingly like the permian mudstone and was only identified by the chance discovery of a fragment of a trilobite. In the more westerly railway cutting were found a few layers, only a couple of inches thick and now standing nearly vertical and very weathered, rich in poorly preserved fossil remains. Included in these were some fragments of trilobites. The fossil suite has yet to be described but it provides a horizon which is capable of recognition through the area from Junee to the Florentine and the key to the stratigraphical succession in this area.

North of the river, white quartzite outcrops. This dips in a northerly direction at a low angle. On the road between Junee township and Storey's the white quartzite is succeeded by yellow mudstones mentioned earlier. These are slightly folded and are easily identifiable as the same series as that in the two railway cuttings although no positively identifiable fossils were found. It is difficult to determine the inter-relationship of the strata forming the two cuttings as only the top of the anticlines are exposed and these are separated by several hundreds of yards of soil and alluvium without exposures of rock. However, from observations elsewhere, it is clear that the two rock types observable in these two cuttings are in very close association. Probably the silky micaceous mudstone of the eastern

cutting immediately underlies the more sandy yellow mudstone of the western cutting. That appears to be the relationship at Sunshine Spur and Tim Shea but it is possible that both types are interbedded. The relationship between the limestone and the mudstone is not discernable in Pillinger's Creek although it appears as if the limestone south of the Juneë-Kallista road forms the western limb of the anticline cut by the railway cutting, thus showing the mudstone as underlying the limestone. Between Juneë township and Juneë Cave the limestone can be seen definitely overlying the mudstone outcropping on the road. (See Twelvetrees, 1908, for a description of Juneë Cave and the limestone in the vicinity).

Twelvetrees refers to an accumulation of dolerite boulders apparent west of the Juneë river and extending for about a mile over Storey's farm and along the Adamsfield track. The present writer can add little to what Twelvetrees has already recorded. These may be the remnants of an old river terrace. Landslips cannot be ruled out as an explanation particularly as a fault is apparent probably running from west of Tyenna Peak to the vicinity of Storeys and indicated by the white quartzite uplifted a few hundred feet above the limestone and forming Sunshine Spur three miles north west of Storeys. Boulders of sandstone amongst the dolerite lend colour to this explanation. A third explanation is possible—namely, that above the limestone and between that rock and the overlying permian mudstone there occurs a sill of dolerite. In two other localities (Chrisp's and Wherrett's Look-out to be mentioned later) the limestone is broken by faults resulting in uplifts westward. In each case there are similar accumulations of boulders and it is quite possible that a sill of dolerite of small thickness has intruded between the lower and upper palaeozoic systems as had occurred between the granite and marine mudstone on the north shore of Reidle Bay, Maria Island. This point is worth further investigation and should be borne in mind in future examinations of areas when this limestone occurs, although the dolerite boulders are only noticeable close to the dolerite of the Mt. Field Plateau.

D. Pine Hill

At Kallista, a steep-flanked whaleback hill of hard white quartzite stands bare of trees for 400 feet above the surrounding forest. This is known as Pine Hill from a forest of celery top pine which once covered it. It is a crush zone of white quartzite and conglomerate heavily mineralized with haemitite and pyrites. The axis of the hill runs a little south of east and north of west and is also the axis of a considerable anticline which has also been crushed into folds approximately at right angles to the main axis. No rock other than ordovician quartzite and its associates is apparent for the whole 500 feet exposed from the summit to the bed of the branch of the Tyenna River which cuts a small gorge round the north western end of Pine Hill. Twelvetrees (1908) first described the rocks of this area as permo-carboniferous but subsequently (1909) expressed some doubts and Reid correctly mapped them as cambro-ordovician. The 'arkose grits' mentioned by Twelvetrees are really the outcrops of the crushed zone in the core of the anticline which are highly impregnated with iron and might be termed a haemitite quartzite. In the lower levels this is replaced by white quartzite very heavily impregnated with pyrites. In fact, the whole ridge of the hill shows promising prospects of mineral impregnation which might indicate an ore body at some depth. It has been prospected almost all over and small excavations are to be seen everywhere. All appear to yield scattered, very low-grade haemitite and pyrite impregnations but nothing payable has been found to date. However, for practicable purposes the surface has only been scratched. Pine Hill to the south of the valley and Sunshine Spur to the north both indicate the intense folding

processes to which this area has been subjected but no necessary connections between the two occurrences is apparent.

The Pine Hill quartzites and conglomerate extend south eastwards for 2-3 miles to the northern side of Pillingers Creek where they have been eroded into a number of sharp hills standing 300-400 feet above the creek bed. No material change in nature or structure is apparent throughout although local variations from white to pink quartzites and to conglomerates are marked. The Pine Hill quartzites are to be correlated with similar rock at Sunshine Spur and the tops of Tim Shea and the Needles and extend with many fault breaks to the foot of those mountains. The evidence elsewhere shows that the quartzite directly underlies the trilobite bearing mudstone. This relationship is obscure at Pine Hill except at the old Kallista Mill where the quartzites dip at a very high angle under mudstones with a similar dip and strike. Pine Hill is a crushed zone arched into an anticline from which the overlying mudstones and limestones have been removed by erosion. Dr. F. W. Whitehouse found some specimens of *orthis* just at Kallista railway siding.

E. Maynes' Farm

This area is 'Lords Selection' mentioned by Twelvetrees. At the old Kallista Mill and extending southward and westward for a mile or so are beds of the Junee mudstone, some 200 feet in thickness. At Maynes' there is an area of rich red soil. No outcrops are visible but in a prospect hole some 10 feet deep at the entrance of the Port Davey track some very decomposed rock was found. Twelvetrees considered that the soil indicated tertiary basalt but only identified the rock from the soil. Reid mapped it as tertiary basalt, i.e. corresponding to the flows at Glenora. It may be the top of an eroded plug but from my examinations of the decomposed rock I am of the opinion that this is a small occurrence of serpentine of the black variety as described by Nye (1929, p. 15) at Adamsfield. No specimen sufficiently fresh to make an authoritative examination could be obtained in spite of much digging but the resemblance with weathered portions of the dyke east of Adamsfield is very close and significant. As similar serpentine is now being quarried at Adamsfield for osmiridium this point is worth further examination by the Geological Survey.

From the top of the clearing at Maynes' Farm to the first branch of Fourteen Mile Creek on the Port Davey Track, about three miles, the rock is quartzite conglomerate resembling that at the top of Pine Hill. Apparently the conglomerate quartzite succeeds the sand-quartzite in all the outcrops in the area. This quartzite is at least 200 feet in vertical depth here but no accurate measurement of the dip and strike was possible. No limestone is apparent west of Pine Hill. Probably a fault runs immediately west of the clearing at Maynes', that is, separating the mudstone and serpentine from the quartzite and the quartzite is another anticline similar to the one forming Pine Hill and striking approximately parallel although on a bearing somewhat nearer north and south.

F. Mt. Mueller

A major fault runs across the eastern face of Mt. Mueller. This is apparent on the rise between the two branches of the Fourteen Mile Creek on the Port Davey Track and on the Kallista tram track about 250 feet below the top of the Tyenna-Styx divide. It apparently runs in a generally straight line. The bearing was difficult to obtain but was approximately south-east north-east. The fault cuts the Port Davey Track on the north-easterly curves on both sides of the larger (western, or second from Maynes') branch of Fourteen Mile Creek and

runs north of the Tyenna-Styx divide (Maydena Range saddle) on the Kallista tram south of Pine Hill. To the north it cuts through the rocky valley which separates the brown dolerite-capped spurs of Mt. Mueller from the white quartzite ridge of the Needles. To the north-east of this fault the rock is white quartzite and conglomerate, to the south-west it is permian glacial tillite, mudstones and Ross sandstones.

The map of Tasmania is so fragmentary that it cannot be used to trace this fault. I have not followed it beyond the Needles to the north and the Styx Valley to the south. It would be wrong to extend the fault line beyond the area in which it has been observed. However, in the district described in this paper, the Mueller fault is a dominating feature. It limits the western extension of the lower palaeozoic rocks and brings in again, to the west, the characteristic rocks which cover the surface eastward of Junee. The Mueller block, however, stands at least 1500 feet higher than the rocks immediately east of Junee and I regard it as an uplifted area rather than the Junee lower-palaeozoic series as a faulted block dividing two portions of a single sequence of permian-triassic rocks. The Mueller block, is not merely a remnant of an unconformable succession succeeding the Junee series lower in the valley and there is no doubt that a fault separates the two. This break cuts in a straight line across all physiographical features, and, throughout, permian-triassic strata lie against ordovician quartzites or mudstones of the Junee series.

I have already described the section of the Mueller block exposed by the Port Davey track (Lewis, 1924) and have nothing further to add except that the tillite appears to be high in the permian and to correspond to the Woodbridge series. Farther south, on the summit of the Tyenna-Styx divide about a mile south-east of where the Kallista tram crosses are some beds of fossiliferous permian limestone. These are very thin and correspond to similar beds throughout southern Tasmania. Between them and the tillite are some hundreds of feet of dark grey, slaty mudstone the exact thickness of which could not be observed on account of the absence of exposures where dips could be measured. The dip appears to be south-west at about 10° . Nowhere could a floor of the permian series be discovered and I regard the Mueller block to be bounded by faults. Twelvetrees records a report of the existence of granite in the Styx valley. This has never been confirmed by observation by a geologist. The locality where it has been mapped falls within the area of permian tillite and there is therefore every probability that observation was of erratics in those beds. I have already recorded tillite unusually full of granite in the Weld Valley not very far distant (Lewis, 1924 p. 22).

To the west and south of Mt. Mueller, ordovician limestones outcrop apparently from beneath the permian strata and overlie white quartzites of the Pine Hills series (Reid, 1921 Pl. X and Lewis, 1924 p. 19). Unfortunately, no such relationship can be confirmed in any locality I have been able to inspect, and I think that the probabilities point to more or less vertical block faulting in small wedge-shaped blocks of intricate pattern. This is to some extent confirmed by the reappearance of permian tillite in the Weld Valley below the 600-feet contour. The details of these faults have yet to be worked out. It appears to be agreed that the limestone overlies the quartzite and conglomerates in the Styx River and Mt. Bowes area as well as elsewhere.

G. The Northern Tributaries of the Tyenna River

White quartzite again outcrops a mile west of the commencement of the Adams-field pack track at Storey's. This rises to Sunshine Spur at 1450 feet two miles further on. Sunshine Spur is another crushed zone of anticlinal form, striking

south west. The quartzite runs in that direction across the valley to meet another anticlinal ridge which runs south east from the southern extremity of the Needles. Sunshine Spur shows at least two lines of intense crushing. These also run south west north east parallel to the anticlinal axis. They are heavily mineralised but only quartz veins and impregnations could be found. They have been well prospected and in one place a tunnel has been driven for a hundred feet or more to cut one of these crush zones, apparently without result.

To the north west of Sunshine Spur the quartzite is dipping at a high angle. It is succeeded by yellow mudstone containing fragments of trilobites which is clearly identical with that described earlier as occurring in the railway cuttings west of Juneë. The mudstone appears to be about 200 feet in thickness and is succeeded by blue limestone of the Juneë series, apparently conformably. In any case, dips and strikes of the quartzite, mudstone and limestone of the series correspond. The mudstone outcrops at the junction of the main Adamsfield pack track and the 'short cut' track which runs over the top of Sunshine Spur. (Forestry Department survey peg F.D. 8 stands at this junction). Some two hundred feet higher up the Spur the blue limestone outcrops. A fault with a throw of some 400-500 feet separates this limestone from the outcrop at Juneë Cave, the fault being marked by the dolerite talus mentioned earlier.

The blue limestone is interrupted by another break which appears to cross the Adamsfield track about $1\frac{1}{2}$ miles east of Chrisp's Hut. This break is marked by a mass of dolerite boulders. These cannot be a river terrace. They may be the result of a considerable landslip on the fault line or may, as mentioned above, be the eroded remnant of a dolerite still lying between the limestone and the overlying permian rocks. At Chrisp's Huts there are quantities of pebbles of grey slaty shale containing permian fossils. Twelvetreë mentions these and records permian strata at no great distance up the hill side north of the huts (which are still in the situation described by him) About $\frac{1}{2}$ mile further west the blue Juneë limestone is again outcropping across the track and can be traced for several hundred feet down the hill below the huts. Apparently a fault separates this occurrence from the limestone east of the dolerite boulders.

It is now suggested that some dolerite underlies the permian fossiliferous mudstone and the last mentioned rock succeeds the Juneë limestone. Further, the real fault break occurs some $\frac{1}{2}$ mile west of Chrisp's Huts from which point the Juneë limestone outcrops to the top of the Tim Shea-Wherretts Lookout saddle where it is again capped by the dolerite of Wherrett's Lookout. The base of the latter dolerite would then correspond with the dolerite and permian mudstone of Chrisp's Huts. If this assumption is correct, the fault would have a throw of some 600 feet and would run east of Wherrett's Lookout. The higher block to the west would form Wherrett's Lookout, that feature having been produced by erosion of the uplifted block and the saddle between that eminence and the main Mt. Field escarpment would mark the lower block to the east of the fault. These faults all appear to be considerably older than the main Mt. Field uplift which cuts across stratigraphic boundaries and has produced an outstanding topographical feature.

Quartzite underlying these limestone beds forms the floor of the valley. The various suggested fault lines could not be traced under the dense forest and soil mantle. It appears that there are either fault breaks or anticlinal ridges crossing the valley in a more or less east-west direction but definite indications were not forthcoming.

In a few places (e.g. Wherrett's Look-out-Tim Shea saddle, the crest of Sunshine Spur and the north east side of Pine Hill) are outcrops of a white sandstone. This is associated with the quartzite-conglomerate but is considerably softer and is more easily weathered. It is probably the same rock as was observed by Hills (1921) on the Tiger Range and by Nye (1929) at Myrtle Creek and confused by them with the Queen River sandstone series. I place it tentatively between the quartzites and the mudstones of the Juneau series. Impressions of orthis and of some other indeterminate fossils are occasionally to be found in it.

H. Tim Shea

This block includes the mountain called Tim Shea (Mt. Stephens) from the saddle west of Wherretts Look-Out, westward to the northern end of the Needles and northward to the Florentine River. The geological structure is quite simple. Quartzite and conglomerate beds are tilting in a general northerly direction at a general inclination of 35° . This gives a vertical escarpment of nearly 2000 feet on the southern side and a simple dip slope on the northern. Mt. Tim Shea is the weathered residual of this escarpment. Some degree of compressional folding is also apparent. On the north-eastern slope of Tim Shea the dip is to a true bearing of 30° and at the western slope this has become a true bearing of about 300° . The change is over a distance of 5 miles and is regular, giving the block a shield shape without apparent break. It may thus be described as a pitching anticline although the fold is very slight in comparison with the dip and the area covered.

The rock of the ridge of Tim Shea is quartzite, quartzite-conglomerate and quartzite breccia. The conglomerate and breccia layers are relatively thin in comparison with the plain sand quartzite. This rock resembles the West Coast Range conglomerate series but may be distinguished from typical exposures of the latter rock in that the pebble contents of the conglomerate are usually smaller, less regularly distributed and the matrix, although sometimes of a rich pink colour is more usually light pink to white or grey. Layers of grits are common and there are layers which contain quite angular fragments and can only be called breccias.

The writer was anxious to investigate the site of Mr. Thomas Stephens' discovery of trilobite remains in 1902. Unfortunately Stephens did not leave any note on this point. R. Etheridge (1904) in describing the fossils gave no more precise locality than 'the Florentine River'. Twelvetrees (1908) who could have discussed the matter with Stephens wrote 'Near the saddle [i.e. between Wherretts Look-out and Tim Shea] are loose stones of yellow oxidised sandstone and clay containing impressions of orthis and trilobites. Although loose they are in such profusion as to suggest the proximity of the bed rock. They are evidently identical with the fossiliferous cambrian sandstone discovery by Mr. Thomas Stephens in 1902 on the flanks of Mt. Stephens, locally known as Tim Shea'. The fossils collected by Stephens and described by Etheridge have not again received comment in published accounts and have acquired an almost legendary importance far beyond their true value. Their locality also has become almost mythical. In 1937 the present writer made a special trip along the Adamsfield track to endeavour to obtain more light on the point. It cannot be stated at this stage that the present Adamsfield track follows exactly the track which was open in 1902 and 1908 but it cannot deviate much through the saddle. On that occasion not a trace either of trilobites or of the yellow sandstone boulders could be found at or near the saddle. That was before the identification of trilobite remains in the Juneau railway cuttings.

The discovery of trilobites at Juneau made it desirable to establish a stratigraphical correlation between these beds and the ones in which Stephens found

trilobites at Tim Shea. An exhaustive search established that a band of Juneé mudstone containing a similar fossil suite including many fragments of trilobites overlies the quartzite which constitutes Tim Shea. These quartzites are dipping at a high angle to the north. A major fault traverses the Wherretts Look Out-Tim Shea saddle. To the east of this fault (between Chrisp's Huts and the highest point of the saddle) is blue Juneé limestone. To the west of the fault from the highest point of the saddle for a mile and a half along the Adamsfield track, the quartzites are exposed and may be traced from the top of the Tim Shea ridge to this point. But a thin band of the Juneé mudstone overlies these quartzites where the soft mudstone is not removed by erosion. This rock is not cut by the Adamsfield track but lies along a contour from 100 to 300 feet above the track from a point about 2 miles west of the saddle almost to the Little Florentine river. This belt is entirely covered by dense horizontal scrub and the mudstones were only discovered in some prospect holes to be mentioned later. It conforms in dip to the quartzite which it overlies. Towards the Little Florentine it is in turn overlain by blue Juneé Limestone which dips conformably. Thus the same ascending sequence of quartzite, mudstone and limestone is again established from this locality. It must have been from boulders of this mudstone that Stephens collected the 'Florentine Valley' trilobites. There can be no doubt that the rock in which these were discovered is the same as that exposed in the railway cuttings at Juneé. 'Northern flank of Tim Shea' is as accurate a location as possible. The writer traced these beds for a distance of about 5 miles, in isolated outcrops, mostly on spurs separating the small gullies which drain this country. The vertical thickness of the beds is about 200 feet but as the dip is at a high angle probably the stratigraphical thickness of the uneroded mudstone beds is less than this figure.

The blue Juneé limestone which outcrops along the Adamsfield track for 2 miles east of the Florentine overlies the quartzite with the trilobite mudstone lying between. This limestone extends for a considerable distance into the Florentine valley (Hills, 1921). Hills recognized that the blue limestone conformably overlay the conglomerates of Tim Shea.

The mountain escarpment of Tim Shea is the direct result of the faulting of this block. Its eastern boundary is clearly marked by the north south fault through the Wherretts Look-Out-Tim Shea saddle which brings limestone into juxtaposition with underlying quartzite, the latter now standing at its summit just over 1000 feet higher in vertical measurement than the limestone east of the fault. The escarpment, so prominent from the south is the actual edge of the faulted block and the slight modification of this by erosion points to a recent date for the compressional movements which have produced this geographical divide between the Russell Falls River Valley and the Florentine Valley.

1. The Needles

This is a block of spectacular peaks of white quartzite reaching an elevation of 3500 feet and running for three miles southward from the western end of the Tim Shea ridge to the north eastern spurs of Mt. Mueller which mass it joins without any material geographical break. The Needles ridge runs approximately north and south. It is separated from Tim Shea by a deep saddle at 2100 feet. A south western plateau extension meets Mt. Mueller. From the south eastern end of the Needles a lower ridge runs south eastward into the Tyenna Valley to meet the south western extension of the ridge known as Sunshine Spur.

The Needles block is the most difficult to interpret of any in the area. At its northern end is a lower extension of pink quartzite dipping 50° to the north west.

These are clearly a continuation of the Tim Shea quartzites. The fault forming the southern escarpment of Tim Shea passes through a saddle between the higher portion of the Needles and this northern extension. A marked stratigraphical break passes down the longer axis of the Needles, as it were, dividing the ridge in half longitudinally. The western half dips to the north west at about 75° (actual dip is difficult to measure). The eastern half appears to dip in several directions—from about 80° to the west in places, through vertical to about 75° to the east. The Needles block is bounded to the south by the Mueller fault and the quartzites here abut against triassic sandstones.

At the foot of the Needles is a small outcrop of slate. This can be seen in the bed of the branch of the Tyenna River which runs from the Needles-Tim Shea saddle past the side of the 'Humboldt Mine' and which is shown on the accompanying plan as Clark's Creek. The slate here is seen to be of dull grey colour weathering to purple with interbedded layers of a yellowish colour. This is the only occurrence of slate in the area. From every point of view it appears to be correlatable with the Dundas slate. Its dip is at 80° to the east. This corresponds with the dip of the neighbouring escarpment of the Needles and at first sight may appear to indicate that the slate overlies the Needles quartzite. However, it does not appear that such can be the case. Nowhere else in the district is such a relationship observable and the top of the quartzite is open for inspection in a number of localities whereas its base is exposed nowhere else.

The writer's tentative explanation is that the Needles block is an overturned fold broken along its longer axis (see Plate V). The result of this movement has been to raise the quartzite bed which now forms the eastern escarpment of the Needles through a vertical position to an angle of 10° or so past the vertical and in the process to expose a portion of the underlying slate. The western side of the Needles ridge has merely been tilted to a very high angle. The eastern flank has been partially overturned across or against the western member. The only other alternative explanation which would fit the actual structure of the block is to postulate that the quartzite of the eastern flank of the Needles is a different series altogether from that of the western flank and of Tim Shea—a quartzite series underlying the slates. There appears no justification for such an assumption. Overturned folding is not uncommon and can produce any degree of successional variations. The writer assigns an early date for this movement (probably late Silurian to Devonian) and contemporaneous with the folding at Pine Hill, Junee, Sunshine and the mineralogenetic phase. There is in the area no indication of earth movements or disruption of the strata in pre-Silurian times.

In addition to this orogenic feature, the Needles appear to have been uplifted as a block in relatively recent times, probably by the same movement as produced the escarpment south of Tim Shea. This elevation was probably subsequent to the movements which caused the Mueller fault and contemporaneous with the uplift of the Mt. Field and other plateaux, i.e. early Pleistocene.

The Sedimentary Succession

The Junee Series

The investigations here recorded establish a definite and easily identified series, which may conveniently be referred to as the 'Junee Series'. The sequence in the type area is:—

7. Grey shales with marine fossils of permian age.
6. Glacial conglomerates.
5. Erosion interval.

4. Diastrophic break.
3. Junee Series. (iii) Blue Junee limestone.
 - (ii) Yellow mudstone containing trilobites and other fossils of lower ordovician age.
 - (i) Quartzites with conglomerates and breccias interbedded.
2. Probable unconformity.
1. Grey slates probably referable to Dundas Series.

The fossils collected from the yellow mudstone at Junee, Sunshine Spur and Tim Shea have been submitted to Dr. T. Kobayashi of Tokyo and Dr. F. W. Whitehouse of Brisbane for identification. The specimens are fragmentary and poorly preserved. Detailed descriptions are published in this volume. Etheridge preferred to assign an upper cambrian age while Kobayashi and Whitehouse, with more material to work on, prefer a horizon very low in the ordovician. The point is not of great importance to Tasmanian stratigraphy. The present view is that the faunal suite does not exactly correspond with that described from anywhere else in the world. On stratigraphical correlations, the present writer assigns an approximately corresponding horizon to the Junee mudstones and the Caroline Creek sandstones although some faunal differences are apparent. It appears preferable for the present to adopt the term 'Junee series' rather than to call these rocks 'Cambro-Ordovician' vague terms which implies, as far as it means anything, a definite correlation not yet established. The underlying quartzite and the overlying limestones must be of approximately the same age as the fossiliferous mudstones. It may be established later that the slates are of cambrian age but there is no justification at present for this assumption.

West Coast Conglomerates and Gordon Limestones

It is clear from the data now forthcoming from this area that either the Tim Shea-Needles-Pine Hill-Sunshine Spur quartzites and conglomerates are not members of the West Coast Range Conglomerate Series or else that series is not the basal member of the Silurian system as developed in Tasmania. For the present, the writer prefers to refrain from attempting to correlate the quartzite developed in this area with the conglomerates capping the West Coast Range. However, the point must throw a disturbing doubt on previously held ideas of the stratigraphical position of the type West Coast Range Conglomerates and direct special attention to the succession elsewhere.

The type Gordon River limestones as described by Gould and developed at the mouth of the Gordon and Franklin Rivers contain fossils of definitely Silurian age. Similar fossils are found in limestones and sandstones at Queenstown, Strahan and Zeehan. None of that suite were found in the area here described and the close association of the Junee limestones with the fossiliferous mudstones, now shown to be of lower ordovician age, clearly shows that the blue limestones as developed at Junee, in the valley of the Florentine and the Vale of Rasselas are not members of the Gordon River limestone series. For the present, they are best termed the Junee limestones and may be assigned a lower ordovician age. The writer considers that they are to be correlated with the limestones at Railton and Melrose in the north of the State.

The Silurian rocks as developed on the West Coast and consisting of the Gordon River limestones, Queen River slates and sandstones and included tuffs and porphyries are entirely missing from the area here described. If they ever existed, they must have been removed by erosion before the deposition of the permian shales as the latter appear to rest directly on the Junee limestones. There is no reason to assume that these rocks were ever deposited in this area.

With the exception of the tiny serpentine (?) outcrop at Maynes' and dolerite sills of trias-jura age capping Mt. Field-Mt. Mueller no igneous rocks were observed in the district. This fact distinguishes the area from those of the western mining fields where silurian sedimentary and igneous rocks occur together.

Correlation with the Adamsfield District

Mr. P. B. Nye in 1929 published an exhaustive report on the adjacent Adamsfield District with an excellent survey map. For many years, the West Coast Range Conglomerates series has been regarded as lying conformably and relatively closely below the Gordon River limestone of silurian age. The present writer makes no comment on this as far as the type localities at the mouth of the Gordon, in the Queen River and at Zeehan go but advances the opinion based on the advantage of the palaeontological evidence referred to earlier, that the Junee and Florentine limestones cannot be correlated with the Gordon River limestones. This fact may throw doubt on some of Nye's conclusions. The present writer has had an opportunity only for a brief visit to Adamsfield and has no comment to add to Nye's exhaustive observations but some revisions may prove necessary in regard to his conclusions on the geological succession at Adamsfield.

Nye (1929, p. 10) records purple slates at Adam River Falls. It is probably that these are members of the same series as the slates east of the Needles. Nye then states that the slates 'are unconformably overlain by the West Coast Range conglomerate series of the Ragged Mountains and Clear Hill, which form the base of the Silurian system in Tasmania'. It has been shown earlier that at the Needles the slates are overlain by quartzites and conglomerates which must be placed low in the ordovician system. Although there is no certain evidence that the Needles and Tim Shea conglomerates and quartzites are of the same series as those at Clear Hill and Ragged Mountain they bear a very close resemblance. The same may be said of the Thumbs and Saw Back conglomerates. Nye then states that these conglomerates are overlain conformably by quartzites followed by limestones. This is the same relationship as at Junee and Tim Shea. The 'numerous casts of a gastropod' is further evidence of the relationship with the Junee mudstone which contains the gastropod figured by R. M. Johnston as *Straparollus (Machireia) tasmanicus* Johnston (Johnston, 1888 pl. V fig. 7) but identified by Kobayashi as a liospirid (?*Sinuspea* sp.).

The present writer therefore considers that the Junee series as defined above is also to be found at Adamsfield and the correlation with the Gordon River limestone cannot be sustained in view of new palaeontological evidence now to hand. This again throws some doubt on the correlation of the sandstones and shales at Adamsfield with the Queen River Slate and Sandstone series. Unfortunately the fossils mentioned by Nye (1929, p. 13) do not now appear to be available for inspection. The point is important as no other occurrence of silurian rocks as far east as this has been recorded. The present writer therefore postulates that the Junee series extends over the Adamsfield area. This is merely a variation in interpretation from Nye's view and does not detract from the value of his observations. The extent of the correction now suggested is that the record of Silurian

rocks from this part of Tasmania should be replaced by rocks of the Junee series (ordovician). The conglomerate-quartzite stage should not be correlated with the West Coast Range conglomerate series until confirmatory data is forthcoming. If a correlation is proved, it will show that the West Coast Range conglomerates are of lower ordovician age and not silurian. It seems to the writer that a major fault cuts off the Thumbs-Denison Range conglomerate from the limestone of the Florentine and Rasselas valleys—a feature recognised by Twelvetreves (1908) and Nye (1929). A correlation between the Florentine limestones and the Thumbs conglomerate is therefore dangerous except on confirmatory evidence from other localities.

GEOLOGICAL STRUCTURE AND TOPOGRAPHICAL DEVELOPMENT

The Junee series is highly contorted and has suffered from extremes of regional metamorphism. This phase of diastrophism clearly occurred prior to the initiation of the permian sedimentation. The area provides no more definite data than this but it is reasonable to assume that the diastrophic phase here was contemporaneous with that in western Tasmania (late silurian to early carboniferous). It was responsible for the extreme folding seen at Pine Hill, Sunshine, the Needles and elsewhere. It is also reasonable to presume a long period of erosion between the diastrophic phase and the permian sedimentation but this area provides no definite data as to this.

It is clear that the lower palaeozoic rocks have not by any means remained stable since the deposits of permian-triassic rocks were laid upon the rocks contorted by the earlier movements. The movements during tertiary times have obscured the results of the shattering effects of the earlier movements which accompanied the intrusion of the huge dolerite sills which are such a feature of Tasmanian Geology.

The final deciphering of the tremendously complicated geological structure of Tasmania will eventually depend on a true conception of what has happened in an area in which lower palaeozoic rocks are in juxtaposition with permian-triassic sedimentaries and their intrusive dolerite. The head of the Tyenna Valley is the nearest area to Hobart presenting such features. It is tragic that, apparently, no complete section of carboniferous-permian strata from the original floor to the Ross sandstone is available for measurement. At Wynyard, the glacial beds, themselves of doubtful horizon within the permian system, are separated from the fossiliferous beds of Preolenna by wide basalt flows which probably conceal numerous faults. At Reidle Bay, Maria Island, we see only the summits of permian mountains rising nearly to top of the sedimentary series deposited on their irregular ridges. Elsewhere only fragments of the permian sediments are exposed. Throughout southern Tasmania the base and even the greater part of the marine series of permian age is below sea level or is obscured by faulted blocks. Even in the Junee district, which is taken as a typical area showing the lower to upper palaeozoic strata, the base of the permian beds is obscured by faulted blocks of older rocks. Some obscure exposure may yet be found (the area immediately above Chrisp's Huts appears promising but the junction is obscured by detritus) and for the present we must recognise that we have no knowledge of the actual thickness of the permian system, its exact geological horizon in relation to beds of similar age occurring elsewhere or the rocks which form its lower horizons.

In the area dealt with in this paper we see from east to west:—

1. The Derwent block at an elevation of 100 feet rising in rounded dolerite hills to an average of 500 feet and consisting of triassic sedimentary rocks, intruded by dolerite with later basalt flows.

- 2.—(a) The Mt. Field block to the north of the Tyenna Valley with permian mudstones at 350 feet to about 900 feet, succeeded by triassic sandstones rising to about 2500 feet and capped by dolerite rising to 4100 feet.
- (b) Corresponding with (a) to the south of the valley, the Maydena Range block rising to about 3000 feet, the lesser altitude being chiefly due to a thinner dolerite cap.
3. The Junee block averaging 1000-1200 feet in elevation with hills rising to 1450 feet and consisting of lower palaeozoic rocks divisible into the Junee series quartzites, conglomerates, mudstones and limestones.
4. The Needles-Tim Shea block rising to about 3500 feet, an obviously uplifted block of the palaeozoic rocks showing a base lower than the Junee series.
5. The Mt. Mueller block, rising to 4000 feet and consisting of permian strata, which, from the exposure at 1400 feet, are obviously lower in stratigraphical horizon than those exposed under the Mt. Field block at 300 feet. These extend upwards to some triassic sandstones at about 2500-3000 feet and are surmounted by dolerite but the whole block does not correspond in any way with the Mt. Field block.
6. The Mt. Bowes block, with Styx-Weld exposure of Junee limestones, corresponding approximately with the Junee block but rising a good deal higher and, in its western half, quartzites and slates, probably equivalent to the Needles quartzites and slates of the Humboldt Mine.
7. The Mt. Anne block, composed of lower palaeozoic rocks corresponding approximately with the Needles-Tim Shea block but capped with intrusive dolerite and rising to 4700 feet.
8. The Mt. Wedge block which corresponds approximately to the Mt. Anne block but with a thinner dolerite cap.
9. The Jubilee Range block which corresponds approximately to the Needles-Tim Shea block.
10. The Snowy Mountains block which corresponds approximately to the Mt. Mueller block.
11. The Mt. Styx block which corresponds approximately with the Mt. Field block and links these areas up with the Mt. Wellington range.

These blocks are bounded by major faults and are themselves much broken by lesser faults. It is very clear that the faulting which produced this pattern was later than the dolerite intrusions although movements contemporaneous with that event are in no wise precluded. The permian triassic sediments have been inclined gently in a general westerly direction. This influence is not apparent in the older rocks because of the previously folded structure of the latter. The influence which has produced this major fracturing appears to have been pressure in an east-west direction with a tilting of enormous blocks of country towards the west leaving marked escarpments along the eastern face of the breaks. There is evidence of some crushing and perhaps overthrusting to a slight degree at the western edges of the blocks (e.g. at National Park and Junee) with further considerable differential movement in a vertical direction along east-west lines of fracture. It is also clear that the uplifting of the plateau blocks was by stages and was sufficiently gradual to leave the pre-existing drainage systems, in the

main, undisturbed. Today the details of the topography are very little affected by rock types and the drainage often cuts at right angles across the structural framework of the area.

Before the geological structure of Tasmania as a geographical entity can be worked out, it is necessary to arrive at a solution of the problem of the dolerite intrusions. A preliminary phase of the investigation of this problem is a determination as to the original western extension of the dolerite sills. Western Tasmania, today, is predominantly occupied by pre-cambrian and lower palaeozoic rocks, the permian-triassic sedimentary series with its masses of intrusive dolerite being only met in relatively small and mutually isolated areas. The problem is whether this result has been produced by an earlier uplift of the western portion of the state followed by a far longer period of erosion than has been experienced over the central and eastern portion assisted perhaps by a thinner dolerite cap or whether it is due to an original westward limit to the newer rocks at much the same locality as we now see the boundary of these rocks against the more ancient groups. The solution of this problem will only be worked out through an intensive study of the whole border line country from New River to Cradle Mountain. The Tyenna Valley is the most accessible portion of this line.

Certain outstanding factors bearing on this problem are now apparent:—

1. The relationship between the older lower palaeozoic rocks and the newer permian-triassic blocks with the intrusive dolerite is in most cases a line or zone of major tectonic faults. As already stated, it is difficult or impossible to find a lower palaeozoic floor for the lowest members of the permian sedimentary series.
2. Dolerite of trias-jura age does intrude lower palaeozoic rocks and in a few places form caps to isolated mountains on which little or no permian-triassic sedimentary rocks are now found, e.g., Mt. Anne and Mt. Wedge (Lewis, 1924) Mt. Sedgwick (with a little permian rock) Mt. Dundas, Eldon Bluff (Johnston, 1888) Cradle Mt. and Barn Bluff (Benson, 1917). Again, the newer rocks are to be found west of the West Coast Range at Pt. Hibbs (Hills, 1914) and Henty River (Johnston, 1888; David, 1924).
3. Over most of the central and eastern portion of Tasmania, although the dolerite is very common it is not found in masses which are relatively extensive compared with the sedimentary rocks which it has intruded, not nearly as extensive as early geological maps would lead us to believe. Further, even in the more extensive occurrences, its thickness is seen to vary very considerably.
4. Along the north coast, pre-cambrian (?) and lower palaeozoic rocks appear at sea level in a number of localities. In other places the same coastal plain is occupied by permian-triassic rocks with intrusive dolerite. Farther inland, the lower plateau and the main central plateau show instances of dolerite and earlier rocks standing at the same level.
5. In general, Tasmanian physiography in its broader outlines appears to be little affected by the change from pre-cambrian and lower palaeozoic rock to permian-triassic series with its intrusive dolerite.

From the factors thus stated, the writer postulates that tertiary block faulting was the dominant influence in moulding the main outlines of our physiography. It also appears that dolerite did extend over the western portion of the State in some

localities at least. From this, however, it cannot be argued that the permian-triassic sedimentary rocks were deposited evenly over the whole of the present Tasmania. In fact, the evidence is to the contrary. (See e.g. Benson, 1917, although there are probably many faults in the Cradle Mt. area which have not yet been identified). The true position is probably that during the permian triassic deposition period there already existed a western land mass comprised of older rock. This was broken by arms of the sea and the newer sedimentary rocks were deposited in places upon the older topography. The whole western segment was gradually sinking and the area covered by these depositions was increasing until, perhaps, the whole of what is now western Tasmania was covered by the more recent members of the group. It also appears that the dolerite extended into or over the western portion of the State much as it did over the central and eastern part although perhaps with larger gaps and thinner sills.

The real influence moulding the existing physiography has been differential erosion caused by differential uplifts at different periods since the dolerite intrusions, including a marked deformation of the land surface at or about the time of the intrusions. Erosion first attacked the blocks which were elevated first and in these blocks it attacked most effectively the areas which were not protected by dolerite caps (many of the pre-cambrian and lower palaeozoic rocks are relatively soft). If this view is correct, western Tasmania must have been uplifted above the central and eastern two-thirds of the state some time in early to middle tertiary times. The uplift need not necessarily have been very considerable but it is clear that a peneplain was produced as evidenced by the general correspondence of the level of the summits of the western mountains irrespective of the age of the rocks. As further evidence we have the easterly flowing rivers, particularly the tributaries of the Derwent and the Huon rising in relatively low country amongst the earlier rocks and cutting straight through the dolerite capped plateaux which now stand considerably higher than the source of many of these rivers. We also have the great accumulations of river conglomerates consisting largely of pebbles of pre-cambrian and lower palaeozoic rocks in river valleys in which those rocks hardly occur. It appears therefore that at some time subsequent to the dolerite intrusions, Tasmania was subjected to tectonic influences which raised the western and north-eastern portion of the State. There followed a long period of erosion during which a single peneplain was produced with a surface occupied indiscriminately by pre-cambrian and lower palaeozoic rocks to the west and north east and with triassic sandstones with their intrusive dolerites in the centre and east. This involves the proposition that the earliest uplift was sufficient to bring the pre-permian floor to the level of the top of the dolerite sills. The actual height of this movement depends on the thickness of the permian-triassic sediments and intrusive dolerite cover of the moving blocks. No indication of this is yet forthcoming and, as already stated, it might not be nearly as considerable in the western portion of the State as the thickness of the corresponding series further eastward. The existence, at the surface, of lower palaeozoic or pre-cambrian rocks today is an indication of the location of this early uplift and not of segments which were not covered by permian-triassic sedimentations or affected by the dolerite intrusions. The subsequent peneplanation removed all the post-permian rocks, and, at least in some blocks, great thicknesses of lower palaeozoic rocks as well. For this reason, it becomes of great importance to study the relationship of the rare silurian series to existing physiography.

The foregoing proposition is now fairly generally accepted as is also the view that there has been more than one series of earth movements (see generally Nye

and Blake, 1938 pp. 12-14). The whole segment of the earth's crust now represented by Tasmania, with probably a large area now submerged, having been reduced to a peneplain after the first block faulting movements and showing a surface covered by pre-cambrian, lower palaeozoic, permian and triassic rocks in faulted blocks, a later (late miocene to pleistocene) phase of differential uplifts in several stages was experienced. The whole of Tasmania was affected and blocks were uplifted irrespective of rock type. It is clear that the faults attributable to this series of movements cut indiscriminately across older and newer rocks and the previous fault system and probably were not affected by the surviving results of the earlier movements. For this reason, any attempt to segregate Tasmanian physiography into areas where pre-cambrian or lower palaeozoic rocks appear on the surface as opposed to those areas where newer rocks only are found, is likely to produce a fundamental misconception. Certainly, difference in hardness of rock types and the relative thickness of dolerite sills has produced a marked effect on the details of the subsequent topography, as also has the relationship of the main fault lines to beds of differing hardness, but the effects of these extend only to details.

It is now the place to consider how the blocks mentioned earlier in this section fit into and illustrate the general statement of physiographic origins just set out. Presuming a topography over the area described in this paper more or less gently sloping towards the eastward as the result of the erosion period prior to the latest uplift the peneplained physiography resulting from the first uplift would have been as follows:—

A more elevated portion of the country consisting of pre-cambrian or lower palaeozoic rocks over what is now the Frankland Ranges was succeeded towards the east by country where lower palaeozoic rocks occupied the surface with small elevated areas of dolerite now represented by Mts. Anne and Wedge, where the dolerite was originally intrusive into lower palaeozoic strata. Then came the Mt. Mueller block of permian-triassic sediments capped with the dolerite of an intrusion originally more than 2000 feet higher than the more westerly examples. This block must have escaped the earlier uplifts and have thus been protected from the degree of erosion which removed the higher levels of the dolerite sills and the triassic-permian rocks from the blocks to the west and south-west. Farther east the Junee block brought the lower palaeozoic rocks again to the surface corresponding approximately to the Mt. Anne-Mt. Wedge blocks but here there was no lower sill of dolerite to afford further protection against erosion. The eastern section of this area was occupied by dolerite covered country now represented by the Mt. Field-Maydena Range and country to the southward. This area was protected from further erosion by its lower elevation, perhaps very little above sea level. This indicates that the western blocks together with the Junee block felt the earlier uplift and consequent erosion to a depth of at least 2000 feet below the stratigraphical horizon affected in the Mt. Mueller block and the country to the eastward, which did not suffer any uplift at this stage. It also indicates the presence of a lower dolerite sill in places, e.g. Mt. Anne and Mt. Wedge, which was missing over much of the Junee block and probably over the country west of Mt. Wedge. At this stage Mt. Mueller probably stood out as the main watershed and the present drainage system was initiated. The country sloped thence southward, northward and eastward over a surface mainly of rolling dolerite hills but occupied in places by lower palaeozoic rocks.

The Mueller, and Junee faults with, probably, many unidentified breaks are the result of the earlier period of block-faulting movements. These have little

effect on present day physiography, a fact which distinguishes them from the more recent fracturing of the countryside, such as the Tim Shea and Mt. Field escarpment faults and points definitely to the existence of at least two phases of earth movements since the intrusive dolerite sills were exposed. It also forms the basis for the proposition that prior to the development of the present topography the surface of this part of Tasmania was occupied by irregular blocks consisting more or less indiscriminately of lower palaeozoic rocks and more recent rocks with their intrusive dolerite sills. Unless this were so, it is difficult to see any explanation for the variety of rock types displayed by neighbouring blocks at the present time nor can this be accounted for by one cycle of erosion since the last uplift in view of the great difference in depth to which different blocks must have been eroded at some time to expose rocks which may have had originally a stratigraphical difference perhaps approaching 10,000 feet.

If the foregoing hypothesis is correct, western Tasmania must have been subjected to block faulting movements at an earlier date than the central and eastern portion of the State. These must have been most intense along the arch of schistose rocks stretching from Cox Bight to Cradle Mt. and from which even the lower palaeozoic rocks have been eroded, assuming that they ever covered this chain of most ancient highlands. Towards the eastern edge of this first uplift the elevation was not felt everywhere and certain blocks were not uplifted at all, even their higher strata thus virtually escaping erosion. The area Weld-Tyenna-Florentine valleys was portion of such a border area of differential uplift and the north and north-western coasts and Fingal districts were other similar areas.

The present topography was initiated by the series of block faulting movements which occurred about the time of the lake deposits containing cinnamon flora generally assigned to the middle-late miocene. It appears that the existing plateaux were uplifted by one influence which exerted similar force over the island, but not sufficiently powerful to uplift the whole country as one block. Each of the plateaux was uplifted separately although more or less contemporaneously and to relatively the same height. The writer inclines to the view that the motion was slightly rotational, that is, tilting of a very considerable area towards the west leaving a sharp escarpment of the east, with, in many cases, an additional escarpment resembling a pressure ridge along the western limits. Each of these blocks is broken by many faults running approximately north and south and is separated from neighbouring blocks by major breaks running approximately east and west. The eastern, northern and southern boundaries of these blocks are marked by lines of parallel or slightly radiating faults bounding blocks which have either lagged in the general uplift from the edge of the moving block or have subsequently subsided. These do not usually present the features of a typical step fault zone as some exhibit features induced by extreme pressure and a study of their stratigraphy indicates that they are really portion of a belt shattered and differentially elevated by the uplifting pressure with occasional regressional movements in phases of adjustment.

It seems that this latest uplift commenced with an elevation of the whole countryside to a height averaging 1400 feet, or acted upon a countryside standing at this average altitude. The moving blocks were elevated to an average height of about 2500 feet with certain segments forced up to 3500-4000 feet and an occasional ridge where higher blocks were pressed against the older highlands to the west rising to 4500 feet. Subsequently there was a slightly but more generally

uplift of 400-500 feet over the whole island. The higher uplifts almost invariably occur along one edge of the 2500-foot uplift.

In the area described in this paper the most prominent uplifted plateau is the Mt. Field-Humboldt Range. This is bounded by obvious fault scarps some 3000 feet high along its western, southern, and eastern faces, although the southern and eastern scarps are somewhat obscured up to about the 2500 feet contour by lower blocks. Mt. Styx forms the edge of a similar plateau to the south and the Maydena Range is a narrow block, probably the residue of the 2500 feet uplift between the two higher plateaux. Mt. Mueller, Snowy Mountains and Mt. Anne are the eroded residuals of similar but smaller uplifts appearing as small segments 4000-4700 feet high rising about larger blocks of country which stands at an average of about 3000 feet.

The Tyenna River and the Styx River flow across the fault scarps of this last phase of uplifts. Very likely the maximum uplift did not affect their original valleys which have eroded through the scarps of the 1400 feet (e.g. at Westerway) and the 2500 feet uplift (e.g. isolating the Maydena Range). The uplift must have been sufficiently gradual to permit these rivers to erode their beds during its progress, as otherwise they would have been diverted northward or southward. They were probably assisted by east and west fault lines or zones. The Florentine Valley is probably flowing across a topography little affected by earth movements since the first phase of uplifting. Its valley is bounded to the eastward by the fault scarps forming the western boundaries of Mt. Mueller and Mt. Humboldt. These faults may have diverted the drainage to the northward from the wide tract of country moulded by the first uplift. Similarly, the Huon flows southward past the Mt. Anne uplift until it turns east and cuts through all the plateaux in its path. The Weld passed down the unaffected country between the Anne and the Snowy Mountains uplift. The Gordon flows in country affected by the first uplift only and its behaviour at the Great Bend is further evidence of this earlier uplift of the western mountains.

Tim Shea is bounded to the south by a fault scarp of obviously recent date. The other faults which cut the Junee River series, although not such prominent physiography features are probably of the same date and appear to be much more recent than the Mueller and Junee Faults. The fault escarpments bounding the western face of the Humboldt plateau and the eastern faces of the Thumbs and Denison Range are the most outstanding elements of the physiography of the area. They appear to have no relationship to the faults which have brought blocks of rock of different stratigraphical horizons to the same level and must be regarded as the results of more recent movements. It appears as if these or relatively contemporaneous movements have also affected the intervening lower palaeozoic rocks, for example, tilting the Tim Shea block to produce its southern escarpment. Similar influences have probably been responsible for the framework of all western mountains. This factor seriously complicates the deciphering of our physiography and before definite results can be achieved the various phases of block faulting must be disentangled.

Saddles and larger physiographic gaps between mountains ranges may be capable of explanation as old river valleys cut off by block faulting uplift and modified by a consequent adjustment of drainage. This explanation is suggested for the saddles to the east and west of Tim Shea, features which are difficult to explain as the result of erosion during the present drainage cycle. The marked difference between the extremely juvenile drainage of the Tyenna valley and the mature

topography of the Florentine Valley can be accounted for by the interruption of portion of an older system by differential earth movements.

As to dates of the earth movements which have produced the dominant physiographic features, the only guide yet forthcoming is that provided by pleistocene glaciation. It appears to the present writer to be certain that the most recent earth movements were earlier than the Yolande glaciation. The presence of lower level (Malanna) glaciation in the Florentine Valley and the apparently uninterrupted glacial topography stretching northwards from Mts. Wedge, Anne and Mueller down the Florentine Valley to the latitude of Wyld's Cragg is an indication that this valley and its bounding ridges have not been materially affected by earth movements since before Malannan (early pleistocene) times. On the other hand, the absence of traces of this glaciation in the equally favourable terrain of the Tyenna Valley is probably due to their removal by subsequent river erosion aided, perhaps, by a slight general uplift of a few hundred feet and a consequent rejuvenation of the lower Derwent.

ECONOMIC GEOLOGY

Although no present mining leases are held in this area, it is not to be dismissed as of no economic importance. Twelvetrees (1908) has described the old Humboldt Mine under the Needles. He records that it was first granted as a gold reward lease. Then a gossan outcrop and a copper lode with a parallel lode of ferro-manganese gossan yielding iron and silver were discovered. Galena and chalcopyrite also occurred. Twelvetrees also records a large gossaneous outcrop of iron oxide between the mine and Juneë. The slate between the site of the mine and the Tim Shea-Needles saddle carries in places large impregnations of pyrites. The mine was only worked between 1891 and 1894 and the various lodes were never opened out effectively. Subsequently, a small amount of work was done by a syndicate who were extracting a considerable amount of barytes in 1919. On the work done to date it would be wrong to condemn the occurrence as of no importance.

Twelvetrees (1909) records scattered boulders of limonite on the south western slopes of Mt. Mueller (See also Lewis 1924) and persistent reports of copper ore in this locality frequently come to hand.

Pine Hill is a highly mineralised area with large impregnations of pyrites and haemitite. It has been trenched all over but no payable ore bodies have been discovered. Sunshine Spur is another mineralised zone. Gold has been found under Mt. Anne (Lewis, 1924). Gold and osmiridium have been washed from creeks throughout the area. Serpentine at Adamsfield is a source of osmiridium and probably of a little gold (Nye, 1929). This rock also occurs in the Styx and Florentine Valleys (Twelvetrees, 1909) and may also occur at Maynes'. It is therefore established that the area carries ore formations. The practical work of investigation has been relatively slight and what has been done shows a grave misconception of the relationship between the geological structure of the country and the possible ore deposits.

With the exception of some possible occurrences of serpentine, no igneous rocks of the group usually associated in Tasmania with ore deposits have been found in this district. The sedimentary rocks, however, have been highly disturbed and the most intense diastrophic phase was probably contemporaneous with the movements which elsewhere produced various suites of igneous rocks and the associated ore bodies.

It is significant that most, if not all, of the major anticlines in the quartzite and conglomerate, the lowest member of the Juneë series, are mineralised and also

that the one definite occurrence of any considerable lodes (Humboldt Mine) occur in the slate series immediately below the quartzite conglomerate bed. It is clear from discoveries already made that the whole area is traversed by mineralized zones. The quartzite conglomerate beds are strongly resistant and would impose a powerful impediment to the passage of the mineral-bearing solutions. Except at the Humboldt mine, only higher layers of quartzite-conglomerate are exposed and, in the zones of the most intense shattering these are impregnated with ores of the lighter minerals which elsewhere often indicate more considerable and valuable ore bodies at a depth. In the one place where the soft slate underlying the tough quartzites are open for inspection, payable ore bodies have been found, but the quartzite-conglomerate (except in the very basal layers) and the overlying mudstone and limestone are unlikely to carry ore lodes.

At some time, some optimist has spent a great deal of energy in digging pits and trenches which can still be traced across Sunshine Spur and from Tim Shea-Wherretts Lookout saddle to the Little Florentine. These were dug in the mudstone overlying the quartzite. Unfortunately, no account was taken of the high angle of dip of both rocks at the localities chosen. From this cause, the rocks prospected are actually overlying the quartzites although they now lie lower on the hill slopes than outcrops of the quartzite. Such a stratigraphical horizon is obviously hopeless in most cases as a site to prospect. The trenches which dot Pine Hill and Sunshine Spur were reasonably sited but only touched the top of the quartzite outcrops. Any possible ore bodies are to be expected to be located some hundreds of feet deeper.

It has been shown that the area holds certain possibilities. Its nearness to Hobart, and the splendid transport facilities available would assist any mining venture. It is to be hoped that some day resources will be available to make a thorough scientific exploration of the likely localities at least to depth of 100 feet below the slate-quartzite junction.

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PLATE VII

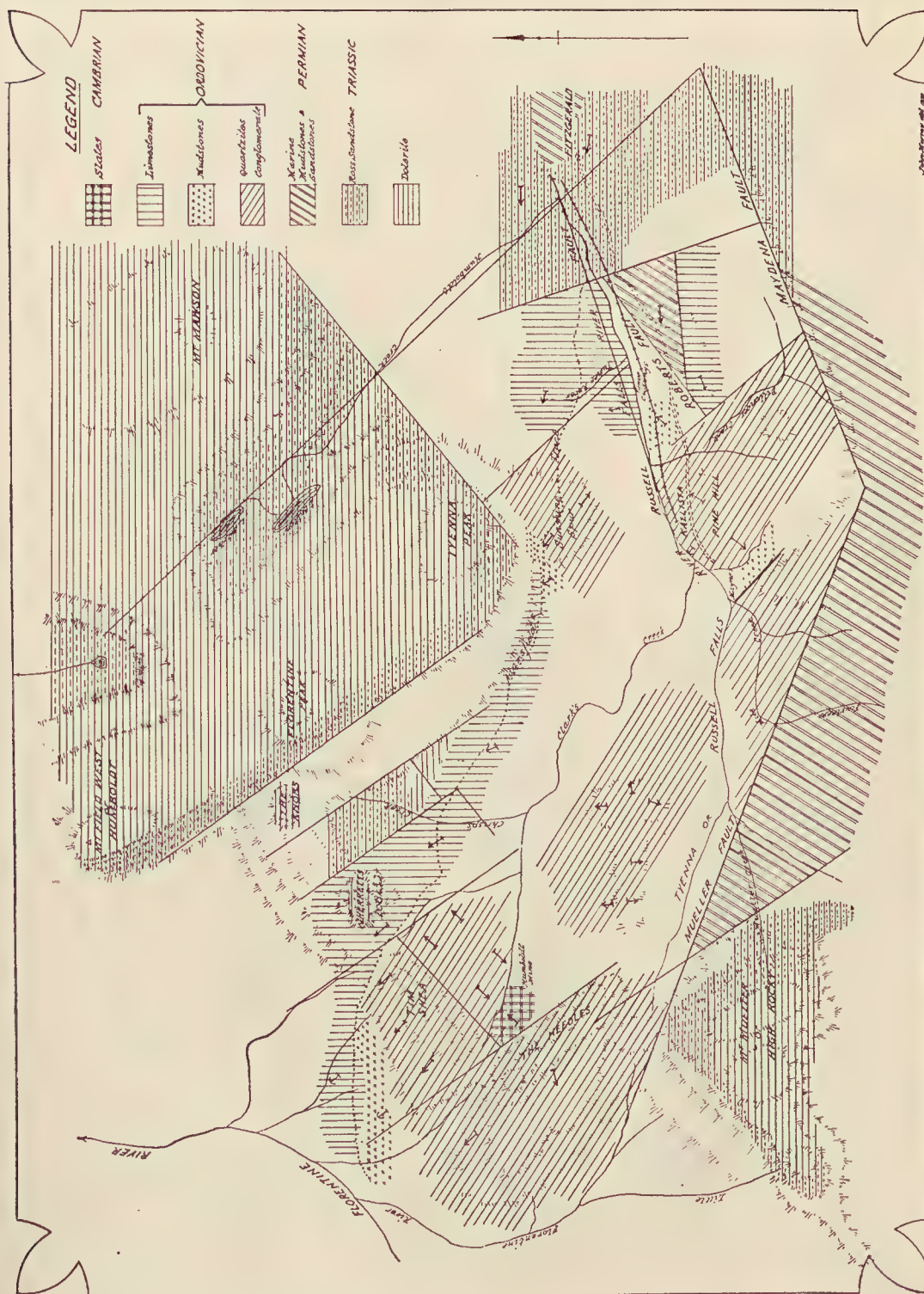
General locality plan. Scale: approx. 1 inch = 16 miles. Vertical interval 1000 feet.



Scale: 1 inch = 16 miles [approx.].

PLATE VIII

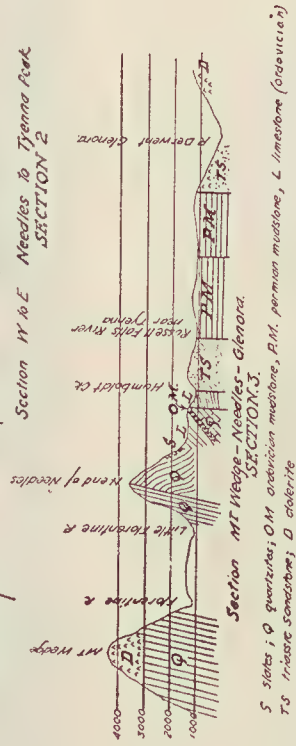
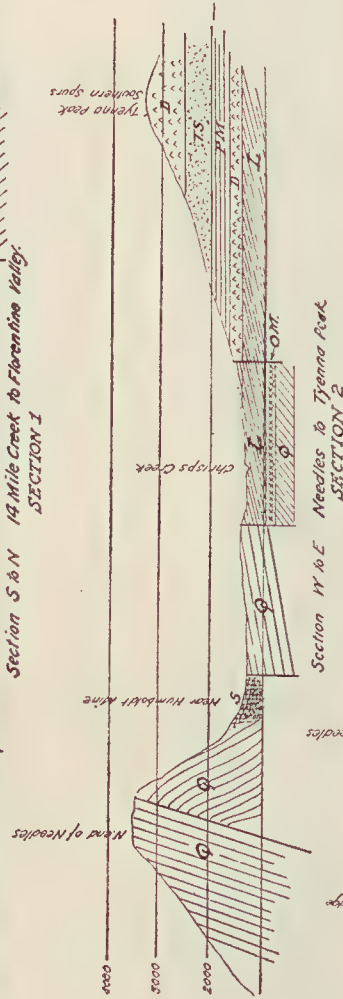
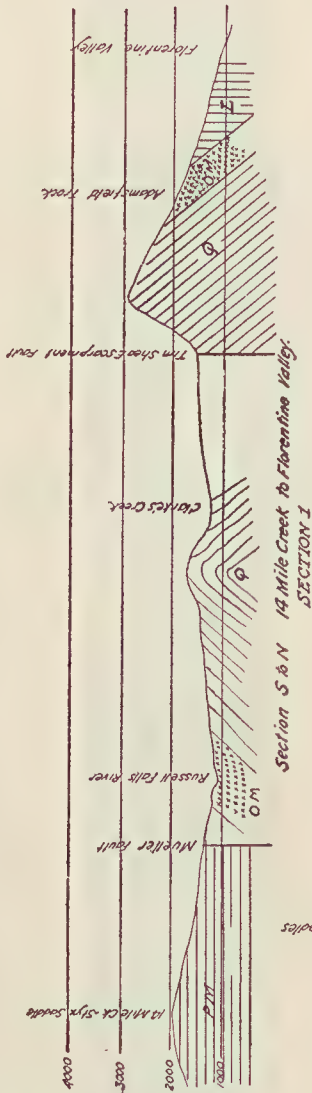
General geological sketch. Scale: approx. 1 inch = 4 miles.



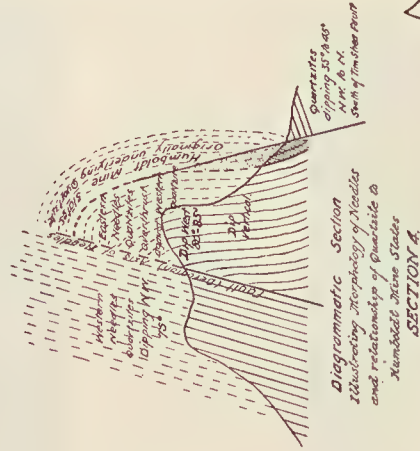
Scale: 1 inch = 4 miles [approx.].

PLATE IX

P.M. = Permian mudstone, tillite, limestone, etc.; O.M. = Ordovician mudstone of Junee series (trilobite bearing); Q. = Ordovician quartzite and conglomerate of Junee series; L. = Ordovician limestone of Junee series; S. = Slate; D. = Dolerite; T.S. = Triassic sandstone.



S. slates; O.M. Ordovician mudstone, P.M. Permian mudstone, L. limestone (Ordovician);
T.S. Triassic sandstone; D. dolerite



Scale: 1 inch = 4 miles [approx.].

PLATE X

FIG. I.—A general view looking north-west from Sunshine Spur. Distance to Mt. Mueller, Tim Shea, and Tyenna Peak, approx. 4 miles.

FIG. II.—Florentine Valley looking north from Tim Shea. Note general glacial aspect. Florentine River flows north in centre of photo. Gordon River flows south on right of Denison Range and then cuts westward between Denison Range and Thumbs. Note Humboldt-Tyenna Peak escarpment which shows permian strata at level of Florentine Valley while Wherrett's Look-Out and site of photo are in ordovician strata at higher level than triassic strata under Humboldt.

FIG. III.—Head of Tyenna Valley looking south-west from Tim Shea. Edge of Tim Shea escarpment shown on right and left of photo. Humboldt mine approx. where "Fig. III." is printed. Triassic strata appear on slopes of Mt. Mueller behind Needles and descend through permian beds to valley on left. Ordovician strata appear at summit of Needles and site of photo. Jubilee Range is of ordovician quartzite. Snowy Mts. are of dolerite capping triassic and permian strata. Note general physiographic accordance of blocks of different stratigraphic horizons.



FIG. I



FIG. II

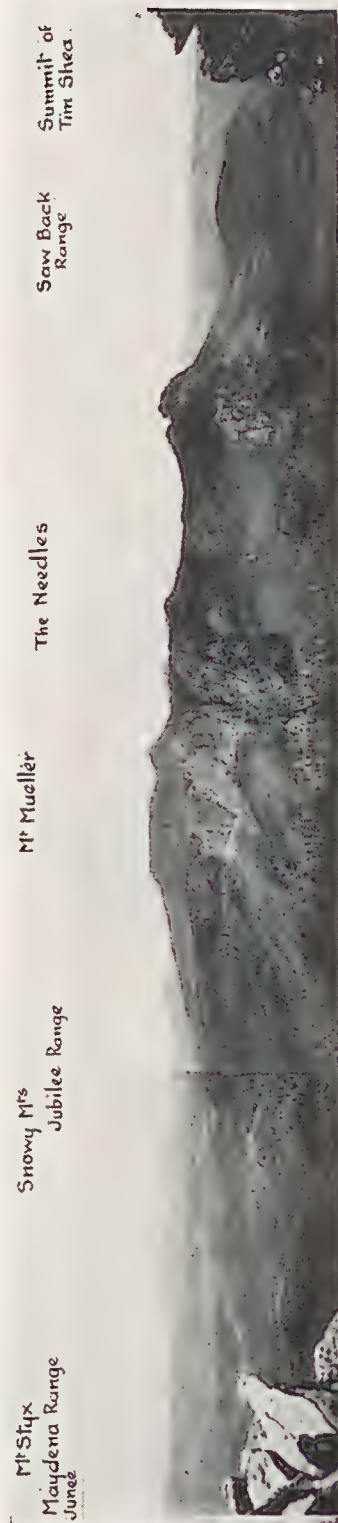


FIG. III

NATIONAL MUSEUM OF VICTORIA

Lower Ordovician Fossils from Junee, Tasmania

By

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(Communicated by A. N. Lewis, LL.D.)

(Read 13th November, 1939)

PLATE XI

This fauna was discovered in a yellowish cream-coloured mudstone at Junee, Russell Falls River Valley, in the western of the two railway cuttings, two miles west of Junee railway station by Dr. A. N. Lewis. He submitted me his collection for palaeontological study and to him I owe many thanks. In the collection, one species of brachiopod, three species of gastropod and four species of trilobites are identified as follows:

Orusia (?) sp.
Sinuopea (?) sp.
Roubidouxia (?) sp.
Lecanospira tasmanensis Kobayashi
Asaphopsis juncensis Kobayashi
Asaphopsis (?) *gracicostatus* Kobayashi
Tasmanaspis lewisi Kobayashi
Tasmanaspis longus Kobayashi

A few brachiopods are contained in the collection but they are not very well preserved. Judging from the outline and numerous fine ribs which increase by intercalation, they may belong to one species. A mould of a ventral valve (Plate XI, fig. 1) shows a strong median septum and suggests the presence of pseudospondylium. A shallow median sinus appears to exist on the mould of the dorsal valve (Plate XI, fig. 2). Although these observations yield nothing definite for generic determination, they suggest a resemblance to *Orusia* or *Finkelburgia*. This species is remarkably similar to *Orusia lenticularis* (?) from the Florentine valley, i.e., Tim Shea, although the ribs appear a little coarser in the specimens described by Etheridge (1905).

Apart from *Lecanospira tasmanensis*, there are two specimens of gastropods one of which resembles *Roubidouxia* or some other liospirid and shows three volutions of a conical spire expanding rapidly and having a round apex. The other specimen exhibits the basal side of the broadly rounded last whorl with an open and deep umbilicus. As fine lines of growth faintly impressed in the latter show a bent backward, it belongs most probably to *Sinuopea* or its allies. The last five species in the list which are better preserved will be described in detail later.

Asaphopsis juneensis in addition to *Orusia* (?) sp. is certainly suggestive of close relationship of this fauna to the Tim Shea fauna. *Asaphopsis* is a characteristic trilobite which ranges from upper Tremadocian to Arenigian in the area extending from Southern France to Western Pacific regions through the Himalayan trough. *Lecanospira* is an American element of gastropod which is common in the Canadian, but ranges down to the Upper Ozarkian by Ulrich which, as discussed in my previous papers (Kobayashi, 1933, 1936), approximates to the Tremadocian according to the European standard. Therefore the two genera warrant the Lower Ordovician age of the fauna, the conclusion being supported also by the presence of imperfect brachiopods and gastropods. Incidentally, *Orusia* ranges from Upper Cambrian to Canadian while *Sinuopea* is common in Ulrich's Upper Ozarkian, although the lower limit of the genus is in the Potsdamian.

It is extraordinarily interesting to see that *Asaphopsis* and *Lecanospira*, distinct faunal elements of two different provinces, are found together at the same locality in Tasmania. *Tasmanaspis* is an endemic genus which may be a relic of a certain Cambrian family of trilobite.

The following is a description of the fossils:—

Family EUOMPHALIDAE de Koninck

Genus *Lecanospira* Ulrich, 1930

Many palaeontologists who followed Salter's generic concept of *Ophileta* had misunderstood the genus until Ulrich and Bridge (1930) pointed out that Salter's diagnosis does not fit in *Ophileta levata* on the basis of which Vanuxem's genus had originally been instituted. On that occasion, the joint authors referred six species to *Lecanospira* of Ulrich as follows:—

Ophileta compacta Salter, 1859, (Genotype) from the Beekmantown group of New York and Canada, Nittany dolomite and Longview limestone of the Appalachian Valley, Roubidoux formation of Missouri.

Ophileta nerine Billings, 1865, Quebec group, Div. F, St. John, Newfoundland.

Ophileta alturensis Sardeson, 1896, from the Oneota dolomite of Minnesota, Wisconsin and Iowa; Gasconade dolomite of Missouri.

Lecanospira conferta Ulrich in Adams, Butts, etc. (1926), same distribution as *compacta*.

Lecanospira sigmoidea Ulrich and Bridge, 1930, from the Roubidoux formation of Missouri

and later Dake and Bridge (1932) added:

Lecanospira sancti-sabae (Roemer) from the Ellenburger limestone (Roubidoux equivalent) in Texas

Still later Powell (1935) described two more species,

Lecanospira tenuis Powell, 1935 and

Lecanospira profunda Powell, 1935, both from the Oneota dolomite of Minnesota.

All of the nine species have so far been confined to the formations in North America which Ulrich referred to the Upper Ozarkian or Canadian. Therefore the discovery of *Lecanospira tasmanensis* in Tasmania, indeed bears, more than ordinary value for the study of palaeogeography.

Lecanospira tasmanensis Kobayashi, n.sp.

PLATE XI, FIG. 11

Shell of medium size planispiral, composed of four or five gradually expanding volutions; spire slightly sunken; diameter of a whorl less than twice that of the preceding; the ultimate whorl tends to detach from the penultimate one. The apertural margin on the umbilical side with the exception of one which shows a part of the apical side. In this specimen, the lateral wall of the last whorl is seen to be moderately convex. There is a low carina on the apical side from which the inner slope forms a concavo-convex curvature. None in the collection shows growth-line or any other facial marking. Most of the specimens are compressed laterally to some degree.

In the cross section of the whorl this resembles *L. alturensis*, but the umbilical side is nearly flat and the volution expands more rapidly in this species. It also stimulates *L. sigmoidea* in the mode of coiling, but the number of coiling is no more than five in this whereas there are six to seven in *sigmoidea*.

Family DIKELOCEPHALIDAE Miller

Subfamily DIKELOKEPHALININAE Kobayashi

Genus *Asaphopsis* Mansuy, 1920

1920. *Asaphopsis* Mansuy, Mem. du Serv. géol. de l'Indochine vol. 7, Fasc. 1, pp. 10-12.

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The genus ranges from Upper Tremadocian to Arenigian and possibly extends into the lower Llandeilian and is distributed in the area extending from Southern Europe through the Himalayan trough to South Chosen on one side and to Tasmania on the other in the Western Pacific region. Eight species and one variety referred to this genus are as follows:

- (1) *Dickelocephalus* (?) *villebruni* Bergeron, 1895 from the Tremadoc superieur of Montagne Noire, Southern France.
- (2) *Dickelocephalus florentinensis* R. Etheridge, jr. 1904, from the Lower Ordovician of the Florentine Valley, West Tasmania.
- (3) *Asaphopsis jacobii* Mansuy, 1920.
- (4) *Asaphopsis reedi* Mansuy, 1920 and
- (5) *Ogygites* (?) *annamensis* Mansuy, 1920 (except the free cheek in fig. 6a) from the Lower Ordovician Dongson sandstone of Thanh-hoa, North Annum.
- (6) (?) *Asaphus elegantulus* Gortani, 1934, (see Gortani, 1934), from the Lower Ordovician of Chisil Pass, Caracorum.
- (7) *Taihungshania welleri* Sheng, 1934, (see Sheng, 1934), and *Taihungshania welleri* var. *brevice* Sheng, 1934, from the Lower Ordovician Yinchufu series of NE Kiente-hsien, Chekiang, China.
- (8) *Asaphopsis nakamurai* Kobayashi, 1936, from the Tremadocian Tomkol shale of Doten-ri, Keisho-hokudo, South Chosen:

Asaphopsis juneensis from June, Tasmania is an addition. *Asaphopsis* (?) *gracilicostatus* from the same locality is, though fragmentary, unquestionably a new species of the genus or an unnamed one closest to *Asaphopsis*.

Asaphopsis juneensis Kobayashi, n.sp.

PLATE XI, FIGS. 6-9

A cranidium in Plate XI, fig. 6 is strongly compressed laterally, reducing its original breadth but, nevertheless, the characteristics of dikelocephalid can hardly be overlooked.

The glabella tapers gently forward and is rounded in front. The axial furrow is rather deep. Three shallow lateral glabellar furrows seen on the left side of the cranidium from the observer are oblique and more or less deepened at a short distance from the axial furrow with which they appear to join. The occipital furrow is transversal, shallow and narrow, and the neck-ring is almost uniform in breadth. On the left fixed cheek is observed a faint accurate groove which encloses a semicircular area adjacent to the glabellar base. The palpebral lobe located on the side of the glabellar center is relatively small, semicircular in outline, and slightly elevated; palpebral ridge almost indiscernible on the specimen. The preglabellar area is as long as two-thirds the glabella, broadly expanded and slightly concave.

In a pygidium in Plate XI, fig. 7 which is not deformed the anterior margin is somewhat arcuate. The axial lobe tapers gradually backward and is divided into more than eleven rings. The pleural lobe may be composed of about ten pleurae, the posterior ones of which are gradually bent backward. Except the articulating one which is regularly convex, the pleural ribs incline gently forward and rather steeply backward, forming terraces. Its marginal border is unpreserved.

Another pygidium in fig. 8 is similarly multisegmented. The same number of pleurae may be counted. The axial lobe is conical and appears somewhat pointed in the hind part. The doublure is considerably broad. A short spine which is a projection of the border issues from the middle point of the postero-lateral margin.

Still another specimen in fig. 9 which is an external cast is depressed longitudinally. The axial lobe is as wide as one-fifth the pygidium. The pleural segmentation becomes gradually obsolete from the axis to the margin until at length it disappears in a broad flat border.

In the last mentioned feature the third pygidium disagrees with the first one in which the furrows pass through the pleural lobe as far as the lobe is preserved on the specimen. Therefore should more material be procured, the difference may prove to be of specific value. Not one of the three pygidia is, however, complete and two of them are deformed rather badly.

Seeing that the doublure covers the outer half of the pygidium in the second specimen and that the furrows die out in the part of the pygidium in the third specimen, the difference of the furrows between the first and third pygidia may be introduced secondarily by the deformation through which the surface-relief was more reduced in the part where the dorsal shield was underlain by the flat doublure. While the third pygidium is depressed antero-laterally the second is compressed laterally. Nevertheless, they agree with each other in the conical axis, its proportion to the pleural lobe, broad flat brim and posterior spine, and the second has the same number of pleurae as the first pygidium. Therefore the reference of the three pygidia to identical species is for the time being, the best suggestion.

The semicircular area in the fixed cheek is the characteristic of *Dikelokephalina* and *Asaphopsis*. The former genus has generally a median postule on the neck ring which is absent in this species. A trace of the eye-ridge which is mostly

distinct in these genera can be seen on one side of the glabella; but on the other side, interrupted by an accidental oblique fold which was caused by the lateral compression, it is almost completely obsolete. The broadly rounded preglabellar field appears to suggest an alliance to *Dikelokephalina* more than to *Asaphopsis* but in the relatively posterior position of the pygidial spine which is one of the chief distinctions between the two genera shows it to be a member of *Asaphopsis*.

This cranidium can easily be distinguished from those of *nakamurai* and *villebruni* by its subcircular preglabellar area. The pygidium of this species is quite different from those of *villebruni*, *nakamurai* and *elegantulus* in outline. The axial lobe is broader and the posterior spine is shorter in this pygidium than in those of *welleri* and *welleri brevis*. The segmentation is more numerous in this than in the pygidia of *reedi* and *jacobi*. If the pygidium of *florentinensis* is correctly illustrated, the pleural groove is much stronger in that species. Besides these distinctions, the nearly straight lateral margin which is subparallel to the axis and the short spine which is produced posteriorly are the distinguishing characteristics of this species.

Asaphopsis(?) *gracilistatus* Kobayashi, n.sp.

PLATE XI, FIG. 10

An incomplete pygidium at hand, insofar as can be judged from its nearly flat or slightly convex marginal border, short postero-lateral spine and pleural ribs which die out gradually within the border, belongs more probably to *Asaphopsis* than to any other genus. A groove along the inner margin of the border may be a crack along the inner outline of the doublure which was introduced by the secondary depression in the dorso-ventral direction.

The most distinct characteristic of this species lies in its fine relatively numerous elevated pleural ribs which are intervened by flat and broad depressions, the feature of which cannot be seen in all other species of *Asaphopsis* so far known. Therefore either this is an aberrant form of *Asaphopsis*, or it belongs to an unnamed genus close to *Asaphopsis*, the decision depending upon the find of other parts of the carapace.

Family ASAPHISCIDAE Raymond (?)

Genus *Tasmanaspis* Kobayashi, n. gen.

This comprises Lower Ordovician trilobites having subovate glabella without lateral furrows with the exception of the occipital one, relatively large eyes close to the posterior of the glabella and the frontal limb and rim forming convexo-concave curvature.

It resembles Upper Cambrian *Blountia* and its allies rather than any Ordovician genera. Its relatively large posterior eyes and faint frontal groove are distinguishing characteristics of the genus.

Type *Tasmanaspis lewisi* Kobayashi.

Tasmanaspis lewisi Kobayashi, n.sp.

PLATE XI, FIGS 3-4

Cranidium broad; glabella subovate, occupying two-thirds the length of cranidium and half the breadth of the cranidium measured through the eyes; circumglabellar and occipital furrows deep; no lateral glabellar furrows; occipital ring

narrows laterally from the median point; palpebral lobes large and opposed on both sides of the glabella in line with its center; palpebral ridge absent; postero-lateral limb of the fixed cheek transversally elongated and grooved along its middle; frontal limb convex in the inner and concave in the outer side and bordered by a narrow and slightly elevated frontal rim; anterior branch of the facial suture describes a semicircle in front of the eye; the suture posterior to the eye transversal and abruptly bent backward near the lateral extremity of the postero-lateral limb of the fixed cheek.

A free cheek found associated with the cranidium is convex and bordered by a narrow groove and rim; genal spine short. The course of the facial suture and curvature of the cheek in adjacency to the suture fit fairly well with those of the cranidium.

Tasmanaspis longus Kobayashi, n.sp.

PLATE XI, FIG. 5

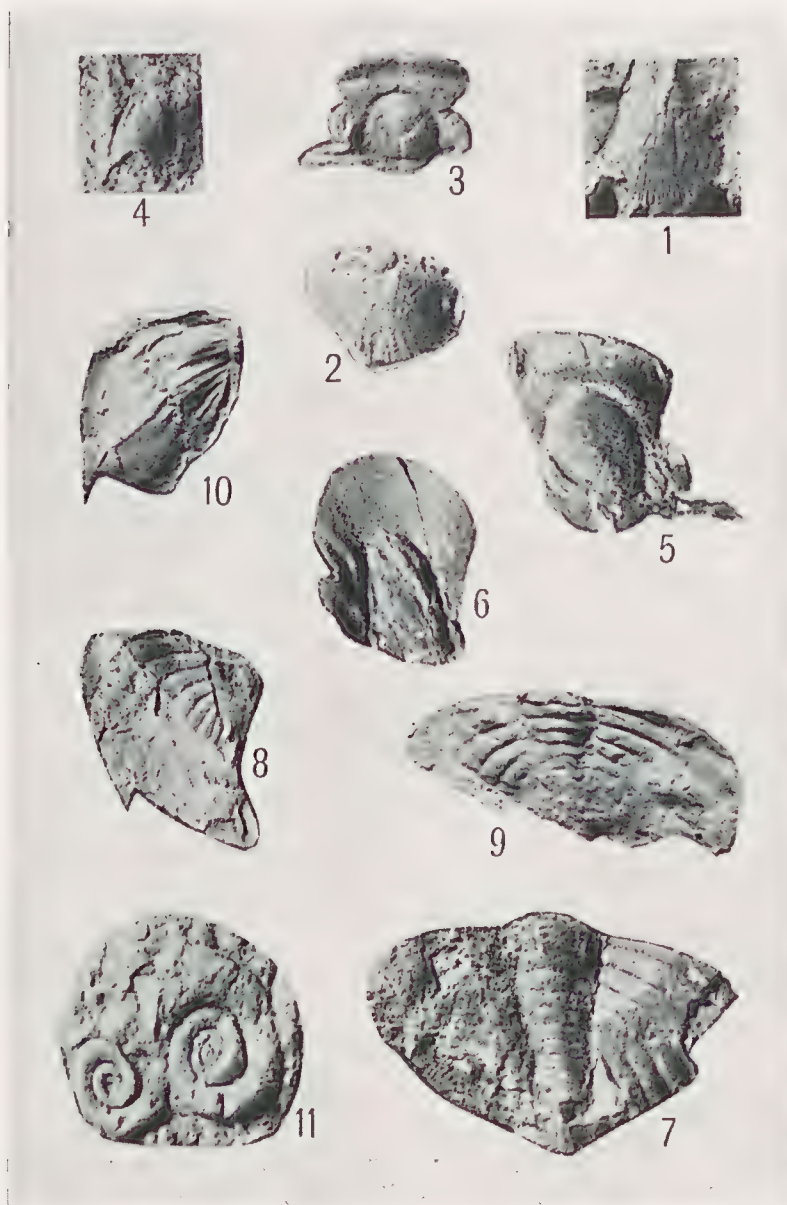
At a glance this appears to be a deformed cranidium of the preceding species by lateral compression, but close examination will soon reveal specific distinctions. This cranidium differs from the preceding in its elongated cranidium, almost straight anterior facial suture, distinct eye-band and uniform breadth of the neck-ring. The length of the preglabellar area corresponds to about half of the glabella in the preceding and to about one-third of it in the present species. Furthermore the palpebral lobe is relatively posterior in this species.

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PLATE XI

- FIGS. 1-2.—*Orusia* (?) sp. Ventral and Dorsal Valves. x2
- FIGS. 3-4.—*Tasmanaspis lewisi* Kobayashi. Holotype Cranidium and Associated Free Cheek. x3
- FIG. 5.—*Tasmanaspis longus* Kobayashi. Cranidium. x3
- FIGS. 6-9.—*Asaphopsis juneensis* Kobayashi. Holotype Cranidium and three paratype Pygidia. Natural size
- FIG. 10.—*Asaphopsis* (?) *gracilicostatus* Kobayashi. Pygidium. Natural size
- FIG. 11.—*Lecanospira tasmanensis* Kobayashi. Umbilical view. Natural size



NATIONAL MUSEUM OF VICTORIA

Lower Ordovician Fossils from Caroline Creek, near Latrobe, Mersey River District, Tasmania

By

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(Communicated by A. N. Lewis, LL.D.)

(Read 13th November, 1939)

PLATE XII

Since Etheridge (1883) described this fauna, the generic references of the trilobites contained have been discussed by Johnston (1888) and again by Etheridge (1919). In 1936 I revised the fauna with fresh material kept in the British Museum of Natural History at London (Kobayashi, 1936). Recently, Dr. A. N. Lewis provided me with a new collection and this paper deals with the results obtained in studying it. Here I wish to tender my sincere thanks to Dr. Lewis for having given me the opportunity to make this interesting study.

The new collection contains most of the known species apart from a few new forms. The determinations by Etheridge and myself are tabulated below:

<i>Etheridge's Determination.</i>	<i>My Determination.</i>
<i>Ophileta</i> (?) sp.	Brachiopod, gen. et. sp. undt. (2 spp.)
	Euomphalidae, gen. et. sp. undt.
	<i>Cryptolites</i> sp. undt.
<i>Conocephalites</i> cfr. <i>stephensi</i> }	<i>Tasmanocephalus stephensi</i> (Etheridge)
<i>Dikelocephalus tasmanicus</i> }	
<i>Asaphus</i> sp. (a)	<i>Asaphellus lewisi</i> , n. sp.
<i>Asaphus</i> sp. (b)	<i>Etheridgaspis carolinensis</i> (Etheridge)
<i>Ptychoparia</i> (?) <i>carolinensis</i>	<i>Etheridgaspis johnstoni</i> (Etheridge)
<i>Ptychoparia</i> (?) <i>johnstoni</i>	<i>Carolinites bulbosa</i> , n. sp.
	<i>Carolinites quadrata</i> , n. sp.
	<i>Carolinites</i> (?) <i>tasmanicus</i> (Etheridge)
<i>Ptychoparia</i> (?) <i>tasmanicus</i>	<i>Prosopiscus subquadratus</i> , n. sp.
	Free cheek gen. et. sp. undet.

The Caroline Creek fauna comprises fourteen species which are distributed in two genera of Brachiopoda, two genera of Gastropoda and five genera of Trilobita among which two indeterminable species of brachiopod, *Ophileta* (?) sp., *Cryptolites* sp. and a detached free cheek of trilobite of which little is known may be omitted in this discussion. *Asaphus* sp. (a) is not contained in the collection at hand, but if the pygidium with the smooth pleural lobe and concave border in

fig. 5 and the forked hypostoma in fig. 7 (Etheridge 1883) be combined in one species, the acquired form would belong to *Isoteloides* or some other genus in the Asaphinae.

Asaphellus is the characteristic Tremadocian genus. The species *lewisi* described in the present paper is near *Asaphellus* but its exact generic position is uncertain. Nevertheless, it is noteworthy that the species is closely allied to *Asaphellus* (?) *stenocephalus* (Mansuy). *Prosopiscus* (?) *subquadratus* resembles *P.* (?) *cheiruroides* which occurs at Thanh-hoi in association with a few species of *Asaphopsis* and *Asaphellus* (?) *stenocephalus*. The generic position of the cheirurids is, however, uncertain. *Tasmanocephalus* is allied to *Chosenia* in South Chosen and *Wutingia* in South Manchuria; both Lower Ordovician members.

Carolinites and *Etheridgaspis* are such peculiar trilobites that it is difficult to settle even their family-references. At a glance, the former resembles *Onchonotus*, especially *O. orientalis* from the Tomkolian of South Chosen (Kobayashi, 1934) but the large oblique eye shows that it is a terminal branch of the Komaspidae rather than of the Solenopleuridae. In the pitted furrows of the glabella the latter looks like *Tostonia* and *Moxonia* but disagrees with them in most other features. It resembles also Irvingellids in the lateral view of the cranidium but the eye is not so developed as in the Irvingelloids. In my opinion, it may indicate an aberrant branch probably of the Solenopleuridae. Of the five trilobites, the former two trilobites in addition to the coiled gastropods indicate the Ordovician age of the fauna and the rest of the trilobites which are presumably relics of the Cambrian trilobite families suggest that the age is of the early part of the Ordovician period, the view being upheld by the inclusion of deeply forked hypostoma of the Asaphidae. The palaeontological evidences so far obtained are, however, insufficient to determine the age with any further accuracy. Through "*Asaphellus*" and "*Prosopiscus*", some affinity of this fauna to that of the Dongson sandstone at Thanh-hoa cannot be overlooked and the latter maintains intimate relations with the Caroline Creek fauna through *Asaphopsis*, but not a single species is found in common between the two faunas in Tasmania. The status appears to suggest a difference of fossil zones.

Finally a question remains as to which is the older between the Junea and Caroline Creek faunas, the solution of which naturally depends upon the field relation between the fossil horizons.

Family CRYPTOLITIDAE Ulrich and Schofield.

Genus *Cryptolites* Conrad, 1838

Cryptolites, sp.

PLATE XII, FIG. 22

A gastropod is contained in the collection but only the last whorl is preserved. It coils in one plane or near to it and expands very rapidly. The umbilicus is as wide as one-third the diameter of the shell. The last whorl may not overlap the preceding one to a great extent. Its section is laterally compressed and its periphery is produced into a carinate band. Several low ribs run straight across the whorl. The aperture seems to be entire and simple.

This would appear to be a member of the Integridorsata of the Bellerophonacea (Reed, 1918) rather than of *Pelagiella*. It is most probably a *Cryptolites* and the straight ribs which are low and relatively wide are a specific characteristic.

Family DAMESELLIDAE Kobayashi

Genus *Tasmanocephalus* Kobayashi, 1936*Tasmanocephalus stephensi* (Etheridge)

PLATE XII, FIG. 1-4

1883. *Conocephalites* (?) *stephensi* Etheridge, Pap. Roy. Soc. Tasm. 1882 (1883), p. 153, pl. 1, figs. 1-3.
 1883. *Dikelocephalus tasmanicus* Etheridge, Pap. Roy. Soc. Tasm. *ibid.* p. 155, pl. 1, fig. 4.
 1888. *Conocephalites stephensi* Johnston, Syst. Acc. Geol. Tasm. p. 37, pl. 1, figs. 3, 4, 14.
 1888. *Dikelocephalus tasmanicus* Johnston, *ibid.* p. 37, Pl. I, fig. 8.
 1919. *Crepicephalus tasmanicus* Etheridge, Trans. Roy. Soc. Austr., vol. 43, p. 390.
 1936. *Tasmanocephalus stephensi* Kobayashi, Japan. Jour. Geol. Geogr. vol. 13, p. 180.
 1936. *Taihungshania tasmanensis* Kobayashi, Japan. Jour. Geol. Geogr. vol. 13, p. 179.

In a previous paper, I proposed the new generic name, *Tasmanocephalus* for *Conocephalites* (?) *stephensi* and referred *Dikelocephalus tasmanicus* to *Taihungshania*. Then I could see neither a cephalon of *tasmanicus* nor a pygidium of *stephensi* in the collection in the British Museum. As I failed again to find either one of them in the other collection now at hand, I am inclined to accept Etheridge's view expressed in the following passage: 'Since my paper was written now many years ago, I have examined a quality of the Caroline Creek deposit. One result of this is inability to find any pygidia likely to associate themselves with the *Conocephalites* cephalon other than the *Dikelocephalus* tail or vice-versa. I can, therefore, only conclude they are one and the same.'

Excepting the presence of two posterior spines, the pygidium in question is different from those of *Dikelocephalus* and *Dikelocephalina* while, on the other hand, it resembles closely that of *Taihungshania* as I have suggested. Then how far the pygidia of *Tasmanocephalus* and *Taihungshania* differ from each other becomes a question. Close comparison shows that the pygidium of *tasmanicus* differs from any of the known species of *Taihungshania* in that the pleural groove is much wider than the pleural ridge, the interpleural groove is, although weak in the young stage (see fig. 4), well developed on the pleural ridge in the later stage of growth (see fig. 3), the extremity of the articulating margin is distinctly angulated, and the marginal border is frequently well defined by a groove. In *Tasmanocephalus*, the spines are widely divergent posteriorly whereas they are nearly parallel in *Taihungshania shui* Sun (see Sun, 1931), *T. shui brevis* Sun, *T. miqueli* Bergeron and *T. miqueli landayranensis* Thoral. As *T. miqueli flexuosa* Thoral (see Thoral, 1935) which is represented by the pygidium only is quite distinct from these forms of *Taihungshania* in its broad triangular outline and spines issuing from the antero lateral points, further study is needed on the species, especially its cephalon, to determine whether or not it really belongs to *Taihungshania*.

At any rate, the pygidium of *tasmanicus* may be readily distinguished from that of *Taihungshania* and it probably belongs to *stephensi*. The genus in which the cephalon and pygidium are combined is indeed, more allied to *Chosenia* (Kobayashi, 1934) and *Wutingia* (Endo, 1935) than I formerly thought. All of the three Lower Ordovician genera agree with one another in the broad cranium, long glabella provided with three pairs of lateral furrows, broad fixed cheek, large posterior eye and free cheek with genal spine on the cephalon and in the depressed marginal border and a pair of spines on the pygidium. The outline of the glabella which is suboviate and bulbous in *Chosenia*, subquadrate, but slightly tapering forward in *Wutingia* and subquadrate but slightly expanding forward in *Tasmanocephalus* is the distinguishing characteristic.

Family CHEIRURIDAE Salter

Genus *Prosopiscus* Salter, 1865*Prosopiscus*(?) *subquadratus*, n.sp.

PLATE XII, FIG. 5

Description:—Glabella square, elevated above the cheek; dorsal furrow very deep; three pairs of lateral furrows short, deep and transversal, but disconnected in the axial part; occipital furrow bent forward in the middle; fixed cheek slightly narrower than the glabella and bent down laterally; palpebral lobe of medium size and opposed to the second lateral furrows; palpebral ridge faintly impressed; facial sutures anterior to the eyes nearly parallel and those posterior to them transverse and cutting the lateral margin at a point in front of the genal angle; frontal rim wire-like and depressed below the glabella; genal spine apparently absent; texture of the carapace unknown.

Comparison:—*Encrinurella insagensis* (Reed, 1906) and *E. martelli* (Reed, 1917) which are common in Southern Asia differ from this species in the outline of the glabella which expands forward in the Asiatic ones and further, in the furrows on the glabella which are disposed in a different manner. *Protopliomerops* has a longer glabella; oblique lateral furrows, more anterior eye and short genal spine. *Prosopiscus minus* (Mansuy, 1920) may be the nearest form but the glabella is longer in *minus*.

Family KOMASPIDAE Kobayashi

Genus *Carolinites* new genus

Diagnosis:—Komaspidae without lateral glabellar furrows and with a narrow fixed cheek, large eyes and a raised frontal rim.

Type:—*Carolinites bulbosa* Kobayashi.

Remark:—This genus can readily be distinguished from irvingellids by its unfurrowed glabella.

Carolinites bulbosa, n.sp.

PLATE XII, FIGS 6 AND 7

Description:—Glabella bulbous, expanded forward; no glabellar furrows except the occipital one which is deep; eye-band long and oblique; no frontal limb; frontal rim straight; marginal furrow deep.

Observation:—A pygidium which presumably belongs to this is semi-circular; axial lobe as wide as half the pygidium, distinctly elevated above the pleural lobe, and composed of three rings and a terminal subtriangular lobe; pleural part narrow, gently convex and faintly ribbed; marginal border of moderate breadth and flat. It is noted that this pygidium is, in the general aspect, allied to the one which I reported from British Columbia and referred to *Irvingellina* (Kobayashi, 1938).

Carolinites quadrata, n.sp.

PLATE XII, FIGS. 8 AND 9

Description:—Glabella convex, subquadrate, slightly expanded forward, highly elevated above the fixed cheek; no furrows on the glabella except a strong occipital one; neck ring narrowing laterally; eye-band, long and oblique; fixed cheek

depressed and bent down to the front and back from the eye; frontal rim straight, wire-like, depressed in front of the glabella and separated from the glabella by a furrow.

Carolinites(?) *tasmanensis* (Etheridge)

1883. *Bathyurus* (?) sp. Etheridge, Proc. Roy. Soc. Tas. 1882 (1883) p. 157. Pl. I, fig. 12.

1888. *Bathyurus* (?) sp. Johnston, Syst. Acc. Geol. Tas. p. 37. Pl. I, fig. 19.

1919. *Ptychoparia* (?) *tasmanensis* Etheridge, Trans. Roy. Soc. S. Australia, vol. 43, p. 392.

This differs from *Carolinites bulbosa* in the presence of a narrow frontal limb, the anterior outline of the cranidium which is gently convex forward, and broad free cheek. If the illustration is correctly drawn and the eye is small, this does not belong to *Carolinites*.

Family SOLENOPLEURIDAE Angelin

Subfamily SOLENOPLEURINAE Kobayashi

Genus *Etheridgaspis* n.gen.

Diagnosis:—Solenopleuridae with long subovate glabella, strong posterior glabellar pits and furrowed pleural ribs on the pygidium.

Type:—*Ptychoparia* (?) *carolinensis* Etheridge.

Remarks:—At a glance, Etheridge's *Carolinensis* in fig. 9 looks similar to the irvingellid in its bulbous glabella, platform-like fixed cheek and the features in the front border, but upon closer study of the collection, I found that the resemblance is not so remarkable. In the irvingellids, the eye is not closely set to the glabella and the fixed cheek is not so narrow. Furthermore, one or more lateral furrows generally run across the glabella in most genera of the Komaspidae except *Dartonaspis*.

As suggested in my previous paper, this genus is certainly more allied to the Solenopleuridae; and especially to *Menocephalites* Kobayashi, 1935, *Hystriocurus* Raymond, 1913, and *Lonchocephalus* Owen, 1852. The last mentioned genus is different from *Etheridgaspis* in its triangularly ovate glabella; occipital spine, broader fixed cheek and frontal limb, unfurrowed pleural rib of the pygidium and so forth. These distinctions except the spine applies to distinguish this genus from *Hystriocurus* and moreover *Hystriocurus* differs from this in its unfurrowed glabella. *Menocephalites* is different from this in the absent frontal limb and broader fixed cheek. Nevertheless it is allied to the three genera of the Solenopleuridae in many respects including the cranidium and pygidium. The narrow fixed cheek, a pair of pits on the posterior part of the glabella and furrowed pleural ribs of the pygidium are the generic characteristics.

Etheridgaspis carolinensis (Etheridge)

PLATE XII, FIG. 10-11

1883. *Conocephalites* sp. Etheridge, Proc. Roy. Soc. Tas. 1882 (1883) p. 156 and 162, pl. 1, figs. 8-9 and (?) 11.

1888. *Loganellus* (?) or *Conocephalites* (?) sp. Johnston, Syst. Acc. Geol. Tasm. p. 37, pl. I; figs. 7, 11, & (?) 16.

1919. *Ptychoparia* (?) *carolinensis* Etheridge, Trans. Roy. Soc. S. Australia, vol. 43, p. 361.

Description:—Glabella large, regularly convex, very slightly expanding backward and rounded in front; circum-glabellar and occipital furrows strong; anterior lateral glabellar furrow indicated by a faint pit at about the middle point of the glabellar side and posterior one by an oblique depression which is pitted at a short

distance from the glabellar side; fixed cheek very narrow; but its posterior lateral limb is long and extends laterally; palpebral lobe relatively large and located slightly posterior to the middle of the cranidium; frontal limb narrower than the frontal rim and they are intervened by a groove; facial suture diagonal and cutting the frontal margin in front of the eye; surface granulated.

Free cheek bordered by a narrow furrow and rim; the marginal rim produced into a short genal spine; eye well developed and elevated above the gently convex free cheek.

Comparison:—I fear that Etheridge's illustrations may not be correctly drawn, because one specimen in figures 8 and 9 and the other in figure 11 which are different in the outline of the glabella and the number and direction of the lateral glabellar furrow were referred to one species. The specimen beforehand fits in neither one of the two exactly, but several characters are common between this and either one of Etheridge's. Mine has two pairs of lateral furrows in the glabella as the specimen in fig. 11. The glabellar outline simulates that in fig. 8, but is longer and slightly expanded in the posterior, although the expansion is not as wide as seen in fig. 11. It is intermediate between the two, but approaches closer to the one in fig. 8.

Etheridgaspis johnstoni (Etheridge)

PLATE XII, FIGS. 12-14

1883. Second species. Etheridge, Proc. Roy. Soc. Tasm. 1882 (1883) pp. 157, 162, Pl. I, fig. 10.

1888. *Loganellus* (?) or *Conocephalites* (?) sp. Johnston, Syst. Acc. Tas. p. 37. Pl. I, fig. 10.

1919. *Ptychoparia* (?) *johnstoni* Etheridge, Trans. Roy. Soc. S. Australia, vol. 43, p. 392.

Description:—Glabella long, conical, gently tapering forward, rounded in front, and distinctly elevated above the fixed cheek; circum-glabellar furrow very deep; anterior lateral furrow shallow and very faint; posterior lateral furrow represented by an oblique deep pit at a short distance from the glabellar side; occipital furrow deep; occipital ring almost uniform in breadth. Fixed cheek very narrow; palpebral lobe relatively large and located at the midlength of the glabella; postero-lateral limb of the fixed cheek extending laterally; frontal limb rudimentary; frontal rim depressed; facial sutures slightly divergent in front of the eyes and widely divergent posterior to them.

Pygidium semicircular, somewhat truncated, even sinuated at the hind; its anterior outline broadly arcuate; axis conical, rounded behind, highly elevated above the pleural lobe which is slightly convex, gently inclined toward the margin and divided by broad furrows into three intrapleural ribs in addition to an articulating one; the rib and furrow almost equally broad; each of the three ribs divided into riblets by an interpleural furrow; the riblet as well as the interpleural furrow run into the marginal border but the intrapleural furrow terminated in the inside of the elevated flat-topped border.

Comparison:—This species differs from the preceding in its narrower and more convex glabella which tapers forward more rapidly. Yet the difference is no more than specific.

At first I thought that Etheridge's *johnstoni* is a different species, insofar as the glabellar outline is concerned. However, as shown in fig. 14, an ill-preserved specimen assumes a similar aspect. Because it is quite probable that his specimen which is incomplete and perhaps incorrectly drawn in his illustration belongs to the same species, I hesitate to establish a new species for mine.

Family ASAPHIDAE Burmeister

Subfamily OGYGIOCARINAE Raymond

Genus *Asaphellus* Callaway, 1877

1877. *Asaphellus* Callaway, Q. J. G. Soc. London, vol. 33, p. 663.
 1910. *Asaphellus* Raymond, Ann. Carnegie Mus. vol. 8, No. 1, p. 37.
 1910. *Asaphellus* Grabau and Shimer, North American Index Fossils vol. 2, p. 290.
 1913. *Asaphellus* Raymond in Zittel-Eastman's Text-Book vol. 1, p. 719.
 1930. *Asaphellus* Reed, Ann. Mag. Nat. Hist. p. 313.
 1934. *Asaphellus* Kobayashi Jour. Fac. Sci. Imp. Univ., Tokyo, Sec. 2, vol. 3, pt. 9.

The association of the detached hypostoma to the dorsal shield of *Asaphellus homfrayi* has been a moot question. Salter's (1866) hypostomata from Garth are distorted. One in fig. 9 which is laterally compressed is parallel-sided; the sides are expanded in the other in fig. 8 which is longitudinally depressed. Both have the elliptical body in addition to the lunate ridge behind. According to Reed (1931) 'the hypostoma which he (Callaway) attributed to *A. homfrayi* more probably belongs to *P. crofti* while that which he referred to the latter should, on the other hand, be assigned to *A. homfrayi*'. Callaway's (1877) hypostoma in fig. 2a shows the maculae divided by a median elevation at the rear. Raymond (1910) noted that the hypostoma of *Asaphellus gyracanthus* is similar to that of *Hemigyraspis colliena*. Only the latter which has the outline tapering backward and rounded at the hind was illustrated. Its macula-bearing ridge appears to be very narrow. Incidentally, *colliena* was later selected for the type of *Bellefontia* by Ulrich (1924). Although those hypostomata of *Asaphellus* differs in minor respects, all agree in the oblong outline, small anterior wings and large central body from which the maculae are distinctly separated. The specimen at hand belongs to this kind of hypostoma.

The isoteliform facial suture precludes this species from *Hemigyraspis* and its unforked hypostoma from *Isotelus*, *Isoteloides* or *Asaphelloides* to one of which it might otherwise belong. At length *Asaphellus*, *Paramegalaspis* and *Megalaspidella* remain for its comparison. When Thor  (1935) established the genus, he overlooked *Asaphellus monticola* Raymond which has been described from the Middle Tremadocian at the Priori near Pierrrerue and L'Chinian, Herault, South France. No mention is, however, given of its hypostoma and with the dorsal shield only its generic separation from *Paramegalaspis* is hardly possible. Thor  compared the hypostoma of the genus with those of *Asaphellus* figured by Callaway (1877) and Matthew (1903) between which Matthew's was later referred to *Asaphellus obtectus* (Raymond, 1924) and Callaway's to *Platypeltis crofti* as mentioned already. The hypostomata of Raymond's *obtectus* as well as Matthew's *A. homfrayi* var. resembles that of *crofti*, instead of *homfrayi* in the subcircular outline. Compared to the hypostoma of *Asaphellus* which is figured out above, that of *Paramegalaspis* is different at least in the size of the anterior wing which is broader in the latter.

When I revised the Cambro-Ordovician shelly fauna of South America (Kobayashi, 1937) I established a new genus, *Megalaspidella*, and *Asaphelloides*, a new subgenus of *Asaphellus*, in the latter of which the hypostoma is slightly forked but the hypostoma of the former was unknown. Recently Harrington (1938) amplified the Lower Ordovician fauna in Argentina in which many asaphids are contained. Among three hypostomata attributed to *Asaphellus jujuanus*, one in figs. 4 and 16 are broad, rounded, and provided with large anterior wings showing the closest alliance to *Paramegalaspis* and then next to *Megalaspidella*.

Judging from their hypostomata, *Megalaspidella* and *Paramegalaspis* are similar but the two can be distinguished from *Asaphellus* s. str. as well as *Asaphelloides* on the dorsal view. *Megalaspidella* is different from the other three in its glabella which is conical, rounded in front, and fairly well defined by the dorsal furrow, and in its pygidium which is segmented as in *Megalaspis*. I do not intend to ignore the classificatory value of the hypostoma, but if the minor difference of it is too highly evaluated, it makes it impossible to determine many of the asaphids. In my opinion, it is most expedient to take *Paramegalaspis* for a subgenus of *Asaphellus*, instead of *Megalaspis*, because there is no distinction of the generic value on the dorsal view, although its hypostoma resembles unforked ones of *Megalaspis*. The difference between *Paramegalaspis* and *Asaphellus* s. str. is in the part where the branching of the posterior into wings begins. Therefore so far as the hypostoma is concerned, *Asaphellus* may stand at about the crossroad whence the three subgenera do not go far astray.

(?) *Asaphellus lewisi*, n.sp.

PLATE XII, FIGS. 16, 17 (?), 18, AND 19

1883. *Asaphus* sp. Etheridge, Proc. Roy. Soc. Tasm. 1882 (1883) p. 156, pl. I, fig. 6.

1888. *Asaphus* sp. indet. Johnston, Syst. Acc. Geol. Tasm. pl. I, fig. 18.

Description:—Cephalon gently convex with a slightly concave border, glabella occupies three-fourths the cephalic length outlined by a shallow furrow; palpebral lobe located at a point one-third the distance from the posterior margin and opposed to each other at the glabellar contraction by which it is divided into a subovate anterior and triangular posterior parts; a medium tubercle found at a point in the posterior triangle; facial suture, isoteliform.

Pygidium semicircular, frontal margin broadly arcuate; axial lobe flat-topped, tapering backward and terminates at a blunt end; no furrows except one near the articulating margin; marginal border slightly concave.

Observation:—The collection contains a cast of hypostoma which is subquadrate, gently expanding forward. Both sides of the posterior outline are rounded. The lateral edge of the hypostoma is conspicuously elevated. Its central body is oval, behind which a crescent-shaped ridge is located. These elevations are clearly figured out by the furrow which is especially deep on the anterior and posterior sides of the posterior ridge delimiting maculae from the main body. The anterior wings may not be very large, insofar as can be judged from the aspect of their attachment.

Comparison:—A free cheek in fig. 17 belongs to an asaphid, but its specific determination is most uncertain, because I cannot trace the anterior course of the facial suture. It has a concave lateral border which narrows backward and hence I cannot determine whether the genal spine is unpreserved or really absent. Putting aside the dubious free cheek, the other parts of the carapace show most features characteristic of *Asaphellus*, namely, the isoteliform facial suture, unfurrowed glabella, tiny median tubercle, unfurrowed pygidium and concave borders on the cephalon and pygidium. The hypostoma belongs to the kind of *Asaphellus* s. str. Although the relative position of the organs may be more or less changed by the secondary distortion, the eye is located more posteriorly than is usual in *Asaphellus*, and further, the glabellar outline suggests the approach to *Megalaspis*. In Eastern and Southern Asia there are several Lower Ordovician asaphids which are allied to this species and they are *Isotelus stenocephalus* Mansuy, *Asaphus*

gigas Dekey var. *hupeiensis* Sun, *Megalaspis* aff. *hyorhina* Herz. von Leuchtenberg, *Ptychopyge thebari* Reed, *Ptychopyge (Basilicus) titanica* Reed, *Asaphellus tomkolensis* Kobayashi, *Asaphellus* (aff.) *gyracanthus* Raymond *Asaphellus* (?) *coreanicus* Kobayashi, and so forth. The pygidium is fairly well segmented in the Burmese form but is obscure in others. In the posterior position of the eye the present species agrees with Sun's species. Mansuy's species agrees with the present species in the form of the axial lobe of the pygidium but differs from it in the position of the palpebral lobe. Although no one can tell what difference will be made out if their hypostomata are discovered, Mansuy's species and probably Sun's species belong to the same kind of Asaphid, as far as the dorsal shield is concerned.

Finally it is noted that Etheridge's *Asaphus* sp. in fig. 6, which was procured from the same locality with the present specimen, most probably belongs to this species so far as I can judge from his illustration.

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PLATE XII

- FIGS. 1-3.—*Tasmanaspis stephensi* (Etheridge), $\times 1\frac{1}{2}$.
- FIG. 4.—Ditto, $\times 3$.
- FIG. 5.—*Prosopiscus* (?) *subquadratus*, n. sp., $\times 1$.
- FIGS. 6-7.—*Carolinites bulbosa*, n. sp., $\times 3$.
- FIGS. 8-9.—*Carolinites quadrata*, n. sp., $\times 2$.
- FIGS. 10-11.—*Etheridgaspis carolinensis* (Etheridge), $\times 2$.
- FIGS. 12-13.—*Etheridgaspis johnstoni* (Etheridge), $\times 2$.
- FIG. 14.—Ditto, $\times 1\frac{1}{2}$.
- FIG. 15.—Free cheek gen. et sup. undet., $\times 2$.
- FIG. 16.—*Asaphellus lewisi*, n. sp., $\times 1$.
- FIGS. 17-19.—Ditto, $\times 1\frac{1}{2}$.
- FIG. 20.—Brachiopod, gen. et sp. undet., $\times 1\frac{1}{2}$.
- FIG. 21.—Ditto, $\times 3$.
- FIG. 22.—*Cryptolites* sp., $\times 2$.



NATIONAL MUSEUM OF VICTORIA

* Notes on the Blood System of the Marsupialia

By

JOSEPH PEARSON

(Read 13 November, 1939)

The following notes were made in the course of a study of the comparative anatomy of the Marsupialia. The heart and great vessels have been reserved for a future paper.

In all thirty-three specimens belonging to the following thirteen species have been dissected:—

- Dasyurus viverrinus* (Native Cat).
- Sarcophilus harrisii* (Tasmanian Devil).
- Isodon obesulus affinis* (Short-nosed Bandicoot).
- Perameles gunnii* (Tasmanian striped Bandicoot).
- Petaurus breviceps* (Lesser Flying Phalanger).
- Pseudocheirus convolutus* (Ring-tailed Phalanger).
- Trichosurus vulpecula fuliginosus* (Brush-tailed Phalanger).
- Phascalomys ursinus* (Island Wombat).
- Phascalomys ursinus tasmaniensis* (Tasmanian Wombat).
- Bettongia cuniculus* (Tasmanian Bettong).
- Potorous tridactylus apicalis* (Long-nosed Rat Kangaroo).
- Thylogale billardieri* (Rufous Wallaby).
- Macropus tasmaniensis* (Forester Kangaroo).

1. ARTERIES ARISING FROM THE BASE OF THE AORTA

There is as much variation in the origin of these arteries in the Marsupials as there is throughout the entire Mammalia, and all stages exist from what may be regarded as a primitive condition to be found in *Phascolaretos*, in which the subclavians and common carotids of both sides arise independently, to the highly specialized condition found in *Petaurus breviceps* in which the four subsidiary arteries arise from the aorta through the medium of a common vessel.

In the following summary I have brought together the results of my own observations together with those of other workers.

A. Four Arteries arising independently from the Aorta

This condition has been described by Sonntag (1921a) in *Phascolaretos cinereus* (Fig. 1).

B. Three Arteries arising from the Aorta

- (a) Right subclavian and right common carotid connected with the aorta by the right innominate artery.

* This work has been carried out under the auspices of the Biological Survey of Tasmania. Most of the specimens which provided material for the present study were obtained by the Biological Survey.

Bettongia cuniculus (Pearson) (Fig. 3); *Phascolarctos cinereus* (Forbes, 1881; Sonntag, 1921b); *Petaurus breviceps* (Sonntag, 1921b); *Phascolomys ursinus* (Forbes, 1881; Sonntag, 1921b; Pearson).

In *Phascolomys* I have found one case in which the right subclavian arose so close to the base of the right common carotid artery (Fig. 2) that it was difficult to say whether this case belongs to Group A or is an intermediate condition between Group A and Group B (a).

- (b) The right subclavian artery arising independently, the two common carotids arising from an innominate.

Dasyurus viverrinus (Cunningham, 1882; Sonntag, 1921b; Pearson). See Fig. 4.

C. Two Arteries arising from the Aorta

- (a) An innominate from which are given off the right subclavian and the right and left common carotids, the left subclavian arising separately.

- (1) The innominate short, with the right subclavian arising near the junction of the innominate with the aorta (Fig. 5).

Sarcophilus (Pearson), *Dendrolagus* (Parsons, 1903) and *Notoryctes* (Sweet, 1904).

- (2) The innominate of medium length, with all three arteries arising from the innominate at the same level (Fig. 7).

Macropus (Sonntag, 1921b; Pearson); *Spilocuscus nudicaudatus* (Cunningham, 1882); *Phascolarctos* (Forbes, 1881; Sonntag, 1921b); *Dendrolagus* (Sonntag, 1921b); *Thylogale billardieri* (Pearson).

- (3) The innominate long, with the right subclavian given off some distance from the base, behind the origins of the right and left common carotids.

Isodon obesulus affinis (Pearson) Fig. 6; *Thylacinus* (Cunningham, 1882); *Trichosurus vulpecula fuliginosus* (Cunningham, 1882; Sonntag, 1921b; Pearson); *Didelphys cancrivora* (Sonntag, 1921b); *Petaurus australis* (Sonntag, 1921b).

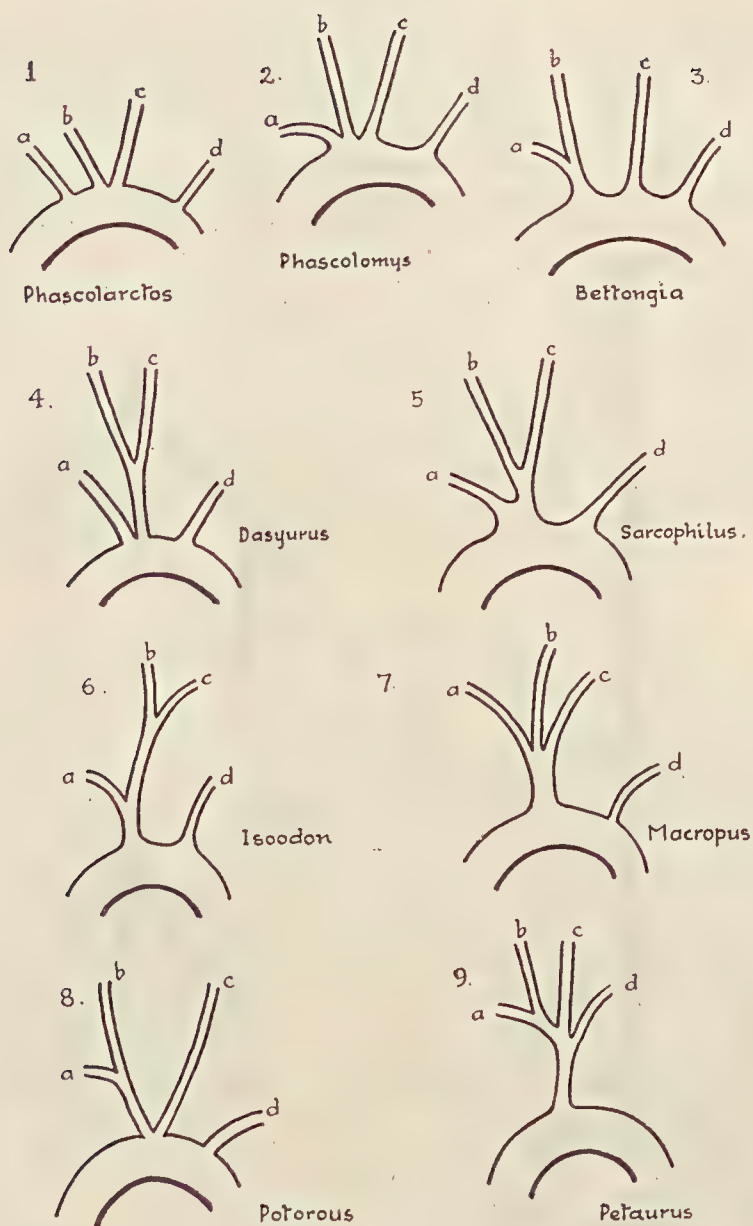
- (b) The right and left common carotids arising together from the aorta, the right subclavian arising from the right carotid. The left subclavian arising separately from the aorta.

Potorous tridactylus apicalis (Pearson, Fig. 8).

D. One Artery arising from the Aorta

So far as I am aware this highly specialized condition is found only in *Petaurus breviceps* (Forbes, 1881; Pearson); (Fig. 9).

Parsons (1902) made a survey of the arrangement of the branches of the mammalian aortic arch, and he was able to show that there was considerable variation in these branches throughout the mammalian series. A careful study of his paper leads one to the conclusion that the method of branching of the vessels arising from the aortic arch is not correlated with the affinities of the various members of the group. From the analysis which has been given above it is obvious that the disposition of the branches of the aortic arch is of no value in determining the relationships and probable evolution of the various members of the Marsupialia. There is, in fact, just as much variation in the arrangement of these arteries within the single order Marsupialia as there is in the whole of the Mammalia.



ARRANGEMENT OF THE ARTERIES ARISING FROM THE BASE OF THE AORTA IN THE MARSUPIALIA

FIG. 1.—*Phascolarctos cinereus* (after Sonntag); FIG. 2—*Phascolomys ursinus*; FIG. 3—*Bettongia cuniculus*; FIG. 4—*Dasyurus viverrinus*; FIG. 5—*Sarcophilus harrisi*; FIG. 6—*Isoodon obesulus affinis*; FIG. 7—*Macropus tasmaniensis*; FIG. 8—*Potorous tridactylus apicalis*; FIG. 9—*Petaurus breviceps*.

a, right subclavian artery; b, right common carotid artery; c, left common carotid artery; d, left subclavian artery.

2. POSTERIOR ARTERIES

After giving rise to the arteries which have been dealt with above, the aorta makes a sudden turn to the left and runs immediately below the vertebral column to the posterior end of the body. In its anterior region the aorta gives off a series of paired intercostal arteries, each of which lies in an intercostal space immediately behind the corresponding intercostal vein (Fig. 10).

A short distance behind the diaphragm the coeliac artery gives off branches to the liver, pancreas, stomach and duodenum. Immediately behind the coeliac artery the mesenteric artery arises, generally near the level of the right renal

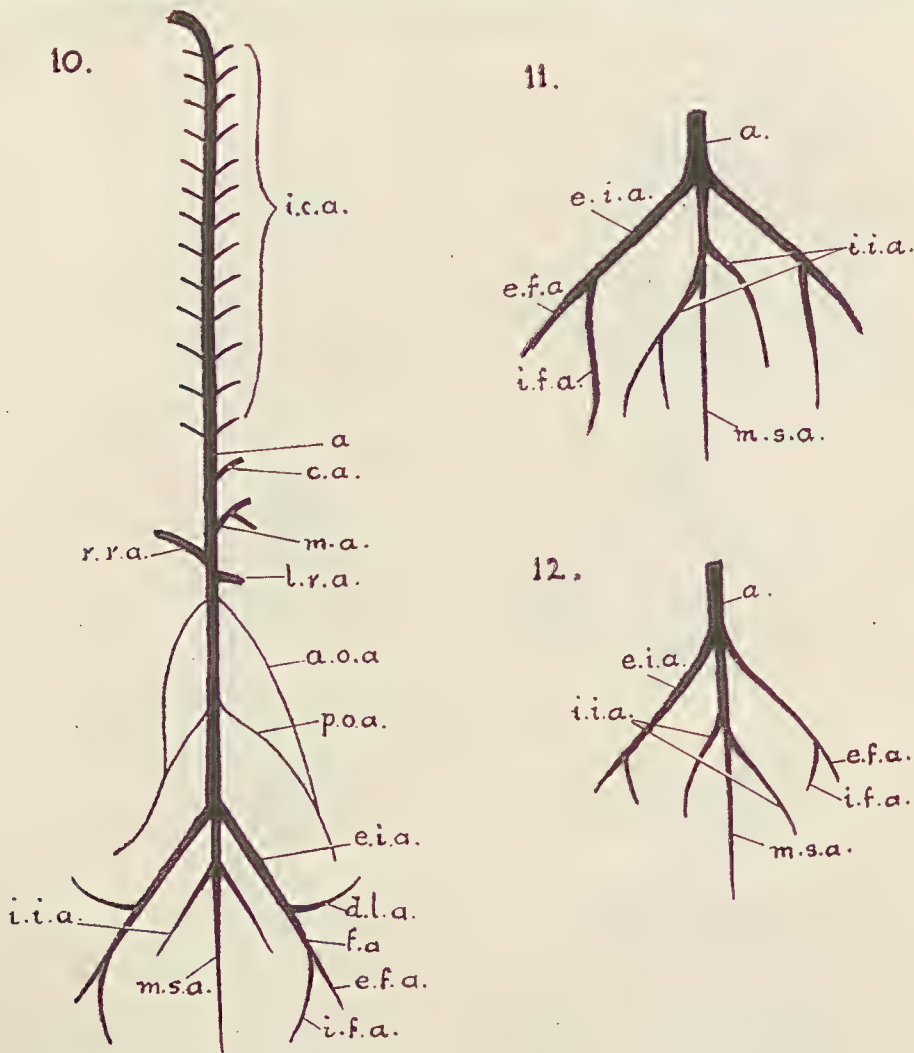


FIG. 10—Dorsal aorta and its branches in the Marsupialia; FIG. 11—Posterior arteries in *Phascolomys*; FIG. 12—Posterior arteries in *Trichosurus*.

a, aorta; a.o.a., anterior ovarian artery; c.a., coeliac artery; d.l.a., dorso-lumbar artery; e.i.a., external iliac artery; i.c.a., intercostal arteries; e.f.a., external femoral artery; f.a., femoral artery; i.f.a., internal femoral artery; i.i.a., internal iliac artery; i.l.a., ilio-lumbar artery; l.r.a., left renal artery; m.a., mesenteric artery; m.s.a., median sacral artery; p.o.a., posterior ovarian artery; r.r.a., right renal artery.

artery. The mesenteric artery divides almost immediately into the anterior mesenteric artery, which supplies the main parts of the intestine and spleen, and the posterior mesenteric artery, which supplies the rectum. This arrangement differs from that in the Monodelphia where the anterior and posterior mesenteric arteries usually arise separately from the aorta.

The spermatic (or ovarian) arteries consist of an anterior pair of vessels which arise from the aorta immediately behind the renal arteries, and a posterior pair which arise from the aorta about half way between the origin of the left renal artery and the point at which the aorta divides posteriorly into the two external iliac arteries. The anterior and posterior spermatics join and supply the reproductive organs. The two external iliac arteries arise from the posterior end of the aorta and immediately behind their point of origin a median artery is given off from which the two internal iliac arteries and the median sacral artery arise. This arrangement differs from that generally found in the higher Mammalia in which the external and internal iliac arteries arise from a common iliac artery. Each external iliac artery passes down the hind limb of its own side and divides into the external and internal femoral arteries. The internal iliac arteries supply blood to the pelvic regions and the bladder. The median sacral artery is continued into the tail as the caudal artery. The right and left internal iliacs are not always given off at the same level (Figs. 11 and 12).

3. ANTERIOR VENAE CAVAE

According to Forbes (1881) and Sonntag (1921b) and confirmed by my own dissections, *Petaurus breviceps* has a single anterior vena cava formed by the junction of the right and left innominate veins, a condition frequently found in the higher mammalia. With this single exception all marsupials which have been dissected have two anterior venae cavae, right and left respectively. Fig 13 gives the arrangement of the tributaries of the right anterior vena cava in *Phascolomys ursinus*, and, with minor variations, this arrangement holds good for all marsupials. In all cases the external jugular vein is the largest vessel returning blood from the head to the heart. The anterior jugular (thyroid) vein, which receives blood from the larynx and thyroid gland, and is connected with the sub-maxillary vein, is generally larger than the internal jugular vein, which runs alongside the common carotid artery. In *Dasyurus viverrinus*, however, the internal jugular is larger than the anterior jugular vein.

Each external jugular vein is made up of five principal branches, namely, the sub-maxillary vein, the anterior facial (external maxillary) vein, the posterior facial (internal maxillary) vein, the post-auricular, and the cephalic, which arises from the radial side of the fore limb.

The sub-maxillary vein runs transversely and receives blood from the sub-maxillary glands and from the region between the rami of the mandibles. It runs across the ventral and inner side of the masseter muscle (Fig. 14). The anterior facial vein passes across the ventral face of the masseter muscle and joins the posterior facial vein, which passes through the substance of the parotid gland. The common vein thus formed almost immediately receives the sub-maxillary vein on its inner and the post-auricular vein, from behind the ear, on the outer side. The above veins form the external jugular, which passes backward ventral to the insertion of the sterno-mastoid muscle and runs on the outer side of this muscle. It then receives the cephalic vein on its outer side and the anterior jugular vein and the internal jugular vein on its inner side. Immediately

posterior to the junction of these veins the common vein thus formed receives the subclavian vein from the fore limb to form the anterior vena cava which passes backwards and opens into the right auricle (Figs. 14 and 15). On its way the anterior vena cava may receive a number of smaller veins such as the sternal (internal mammary) vein, the vein which receives the anterior intercostal veins, and the azygos vein.

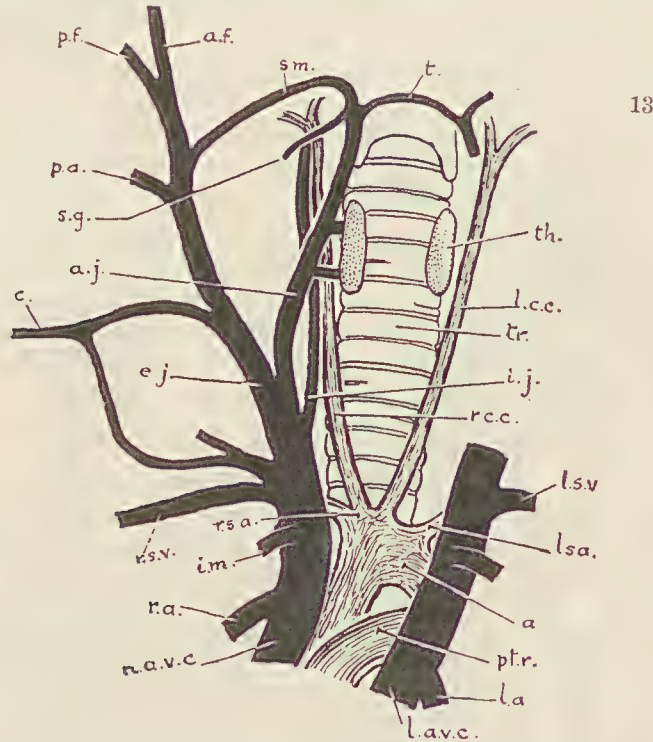


FIG. 13.—Blood system of neck region in *Phascolumys*.

a., base of aorta; a.f., anterior facial vein; a.j., anterior jugular vein; c., cephalic vein; e.j., external jugular vein; i.j., internal jugular vein; i.m., internal mammary (sternal) vein; l.a., left azygos vein; l.a.v.c., left anterior vena cava; l.c.c., left common carotid artery; l.s.a., left subclavian artery; l.s.v., left subclavian vein; p.a., post-auricular vein; p.f., posterior facial vein; p.tr., pulmonary trunk; r.a., right azygos vein; r.a.v.c., right anterior vena cava; r.c.c., right common carotid artery; r.s.a., right subclavian artery; r.s.v., right subclavian vein; s.g., vein from submaxillary gland; s.m., submaxillary vein; t., transverse vein; th., thyroid gland; tr., trachea.

4. THE AZYGOS SYSTEM

Among the important vessels returning blood to the heart from the posterior region of the body are the postcardinals, two veins which usually form an important constituent of the renal portal system of the more primitive vertebrates and which make an early appearance in the development of the Mammalia. Originally the blood from the posterior region of the body enters the heart by way of these vessels, but after the formation of the posterior vena cava, a relatively new vessel, the postcardinals gradually lose their importance and ultimately become cut off from direct contact with the posterior region of the body.

It is usually agreed that the azygos veins of the Mammalia are vestiges of the anterior portion of the post-cardinal veins. McClure (1906) showed clearly that

in the case of the American marsupial *Didelphys* the azygos veins and the postcardinals are present at the same time in an 8 mm. embryo. In this genus the azygos veins are apparently formed by the anastomosis of a series of lateral offshoots of the postcardinals, and the two sets of veins remain connected for some time by a series of transverse vessels. Ultimately the postcardinals disappear and the left azygos grows considerably, while the right either disappears altogether or remains as an insignificant vessel, receiving veins from not more than five intercostal spaces.

Beddard (1907) describes an interesting condition in the newly-born South American rodent *Myopotamus*. In the thoracic region there were two vessels connected with the right precaval and one with the left precaval. In Beddard's opinion these represent a right and left postcardinal and a single right azygos.

It would appear that the homology and origin of the azygos veins vary in different mammals. Beddard suggests that the true azygos is always a single vein and that when right and left vessels are present they are either two postcardinals or a single azygos and one persistent postcardinal. This, however, is not borne out by McClure's investigations into the venous system of *Didelphys*, and the investigations of other workers show that there is apparently no hard and fast rule for the development of the azygos veins, but that in most cases they are either the actual vestiges of the postcardinal or are derivatives of them. The problem of the homology of this system of veins presents many difficulties, and it is probable that the development of the azygos system is not uniform throughout the Mammalia.

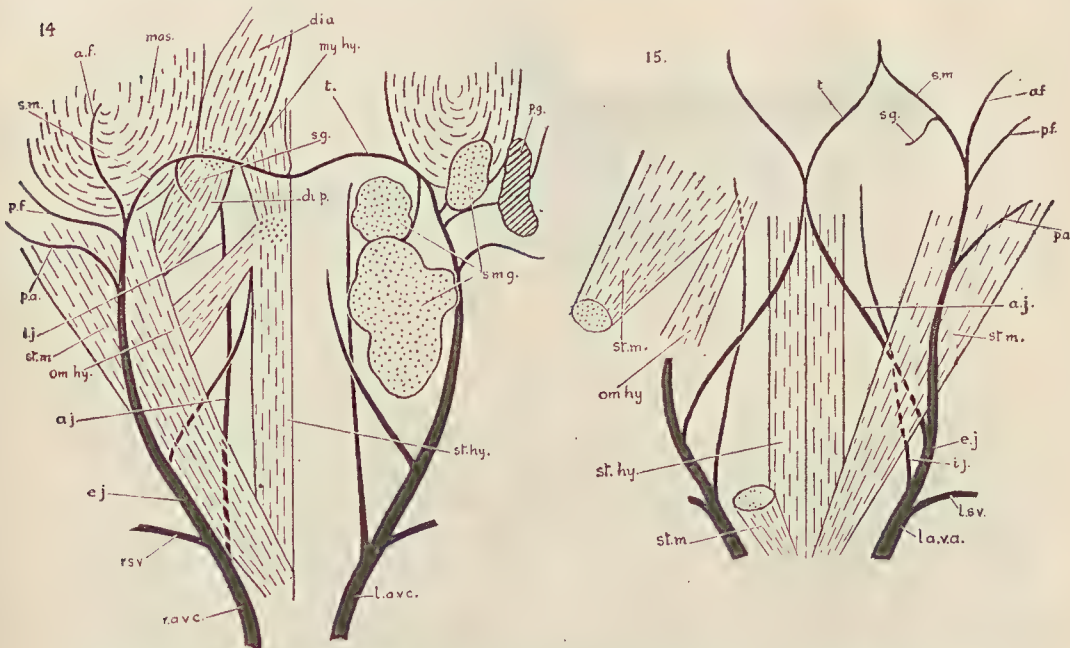


FIG. 14—*Dasyurus viverrinus*. Veins of the neck. On the right side the submaxillary and parotid glands have been removed. On the left side the muscles are not shown; FIG. 15—*Sarcophilus harrisii*. Veins of the neck. On the right side the sterno-mastoid muscle has been cut.

dia., digastric muscle (anterior part); *di.p.*, digastric muscle (posterior part); *mas.*, masseter muscle; *my.hy.*, mylo-hyoid muscle; *om.hy.*, omo-hyoid muscle; *p.g.*, parotid gland; *s.m.g.*, sub-maxillary glands; *st.hy.*, sterno-hyoid muscle; *st.m.*, sterno-mastoid muscle. (Other references as in fig. 13.)

The azygos veins are variable in the Mammalia, and occur either as paired vessels returning blood from the intercostal spaces to the anterior venae cavae, as in many Marsupials, Rodents, Insectivores and Artiodactyles, or as a single vessel returning blood from the intercostal spaces of both sides, the right azygos in some Marsupials, Carnivora, Edentates, Lemurs and Primates, and the left in some Marsupials, Rodents and Artiodactyles (Beddard, 1907, p. 222).

Within the Order Marsupialia, the azygos veins show a great variety of arrangement. Milne-Edwards characterized the group as having two azygos veins equally developed and the great comparative anatomist, Richard Owen (1841), concurred in stating that the azygos veins in the Marsupialia 'retain their original separation and symmetry.' It would be more correct to say, however, that although the azygos system in the marsupials is based upon the essential plan of the primitive posterior cardinals, more often than not the original symmetry has been lost and all conditions may be found from the double azygos of *Phascolomys* to the condition found in *Didelphys* where the right azygos is usually absent.

With the exception of *Phascolomys*, which has 15 pairs of ribs, most marsupials have 13 pairs, and the intercostal veins run immediately posterior to the ribs alongside and anterior to the corresponding intercostal artery. Generally speaking, the azygos system is linked up with all the intercostal veins except the first two or three pairs. Usually the left azygos enters the left precava slightly posterior to the level of the entry of the right azygos into the right precava. The oesophageal vein enters either the right or left azygos vein (Fig. 16).

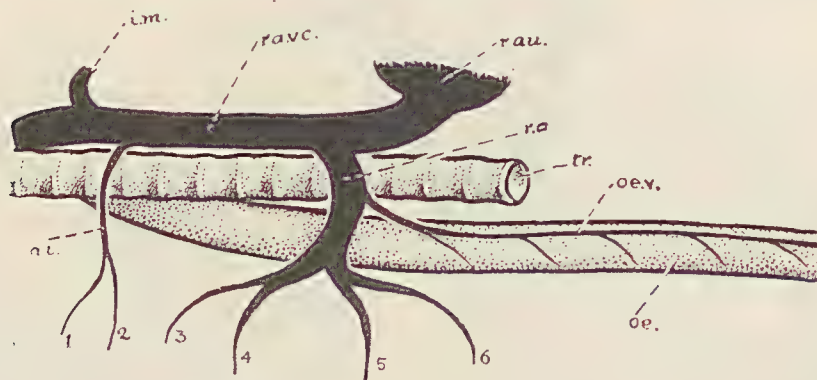


FIG. 16—*Sarcophilus harrisii*. Lateral view of azygos vein of right side (the complete system is seen in fig. 26).

a.i., right anterior intercostal vein receiving the veins from the 1st and 2nd intercostal spaces; i.m., internal mammary (sternal) vein; oe., oesophagus; oe.v., oesophageal vein; r.a., right azygos vein; r.au., right auricle; r.a.v.c., right anterior vena cava; tr., trachea.

In the marsupials, the azygos system is rarely connected with the veins of the first two intercostal spaces.* The arrangement of these anterior intercostal veins would appear to vary considerably in different forms. In *Didelphys* McClure (1903) has shown that the blood from the first two intercostal spaces is collected by the superficial superior intercostal veins which open into the anterior venae cavae. He has also shown that these veins anastomose with the deep superior intercostal veins and as Beddard (1907) has pointed out, these latter veins may, in some cases, be the sole means by which the contents of the first two intercostal veins are returned to the heart. There is still a further possibility. The right and left sternal (internal mammary) veins receive blood from the

* In figs. 17-27 which deal with the azygos system the first two pairs of intercostal veins are not shown.

ventral portion of the intercostal spaces and open into the anterior vena cava and possibly in some cases this may be the only means by which the blood from the anterior intercostals is returned to the heart. Very rarely the anterior intercostals actually open into the azygos. In some marsupials which I have dissected it has been difficult to trace the two anterior intercostal veins and occasionally these vessels enter the anterior vena cava by a common vein which does not appear to have any relation to the vessels mentioned above.

For instance, in *Thylacinus* Cunningham (1882) showed that the first three intercostal veins of the right side open into the right anterior vena cava by a single vein which is distinct from the azygos. Similarly on the left side where there is no azygos the first three intercostal veins open into the left anterior vena cava by a single vessel. I have found a comparable state of things in *Sarcophilus*. Here the blood from the first two intercostal spaces opens into the anterior vena cava of each side by a single vein which is not connected with the azygos veins (Fig. 16) which in this form are present on both sides. A similar arrangement has also been noted by me in *Perameles gunnii*. The veins receiving the anterior intercostals in the above instances do not appear to be either the superficial or deep superior intercostals.

McClure (1903) and Beddard (1907) have summarized the findings of previous observers with regard to the disposition of the azygos system in Marsupials.

McClure considers that the azygos system may be arranged in three different ways, viz.,

1. Right and left azygos veins equally developed.
2. Right azygos vein only developed.
3. Left azygos vein only developed.

This statement of the case is misleading, as it suggests a clear cut separation into three distinct types, a distinction which does not exist, and no allowance is made for intermediate types between 1 and 2 and between 1 and 3. If a sufficiently large number of specimens of each marsupial species were examined I do not think that there are many (if any) species in which traces of both right and left azygos veins are not sometimes present.

Beddard's interpretation is more satisfactory, in this respect as he includes these intermediate types and recognizes five different arrangements of the azygos system, viz.,

1. Right and left azygos, equal or nearly equal.
2. Large right azygos, small left azygos.
3. Azygos on right side only.
4. Large left azygos, small right azygos.
5. Azygos on left side only.

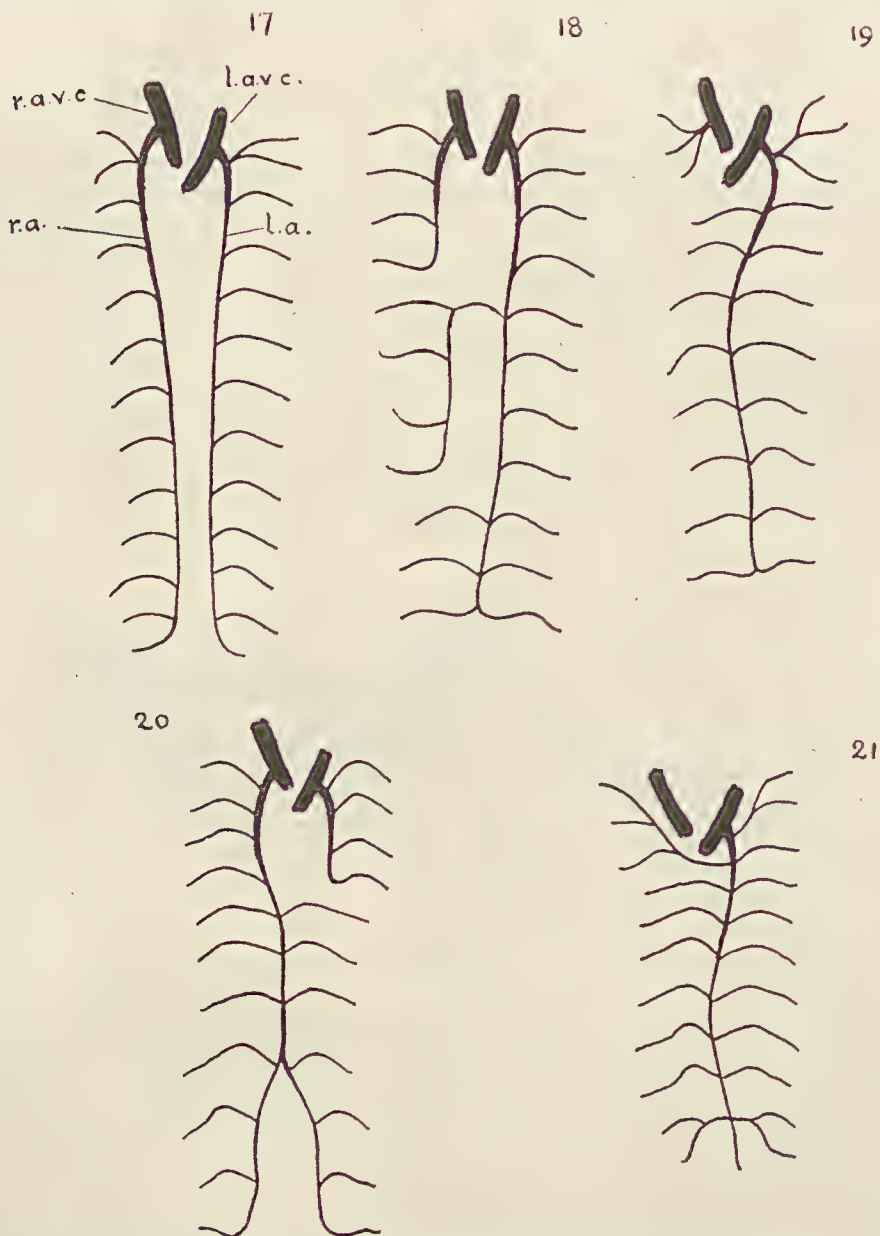
But even Beddard's classification does not meet all cases, although it may be regarded as being sufficiently true as a general statement of the case.

The following is a statement of the results of dissections of the azygos system in the course of the present investigations. If these are added to Beddard's list, a fairly complete knowledge of the arrangement of the azygos system in the Marsupials can be obtained:—

1. Right and left Azygos Veins equally developed

Here the intercostals of each side drain into the azygos of the same side. I have found this arrangement consistent in six specimens of *Phascolomys ursinus* which I have examined (Fig 17). Forbes (1881), however, gives a case in which the right azygos of *Phascolomys* was extremely small and most of the intercostal veins opened into the left. There was, however, a small connexion between the

posterior intercostal vein opening into the right azygos and the anterior intercostal of the right side which opened into the left azygos and this connexion probably indicated a relic of the right azygos.



TYPES OF AZYGOS SYSTEM IN THE MARSUPIALIA

FIG. 17—*Phascologomys*; FIG. 18—*Potorous*; FIG. 19—*Pseudocheirus*; FIG. 20—*Thylogale*; FIG. 21—*Isodon*.

l.a., left azygos vein; *l.a.v.c.*, left anterior vena cava; *r.a.*, right azygos vein; *r.a.v.c.*, right anterior vena cava. (The lettering in fig. 17 applies to all five figures.)

In a specimen of *Bettongia cuniculus* which I dissected both right and left azygos veins were fully developed though the right was thinner than the left.

Out of three specimens of *Sarcophilus harrisii* examined by me one came under the present category (Fig. 25) though in the others the right azygos was poorly developed.

2. Left Azygos well developed. Right Azygos relatively small

In this category the left azygos receives not only the left intercostal veins but also the posterior intercostal veins of the right side (Figs. 18, 19).

In one example of *Dasyurus viverrinus* the right azygos was almost as long as the left and only the three posterior intercostals of the right side drained into the left azygos (Fig. 22.)

In specimens of the following species I found the right azygos small and draining only two to four intercostal spaces.

Dasyurus viverrinus (Figs. 23, 24).

Perameles gunnii.

Potorous tridactylus apicalis (Fig. 18).

Sarcophilus harrisii (Figs. 26, 27).

Trichosurus vulpecula fuliginosus.

Pseudocheirus convolutor (Fig. 19).

3. Left Azygos well developed. Right Azygos absent.

Here the intercostal veins of both sides drain into the left azygos.

Isodon obesulus affinis (Fig. 21).

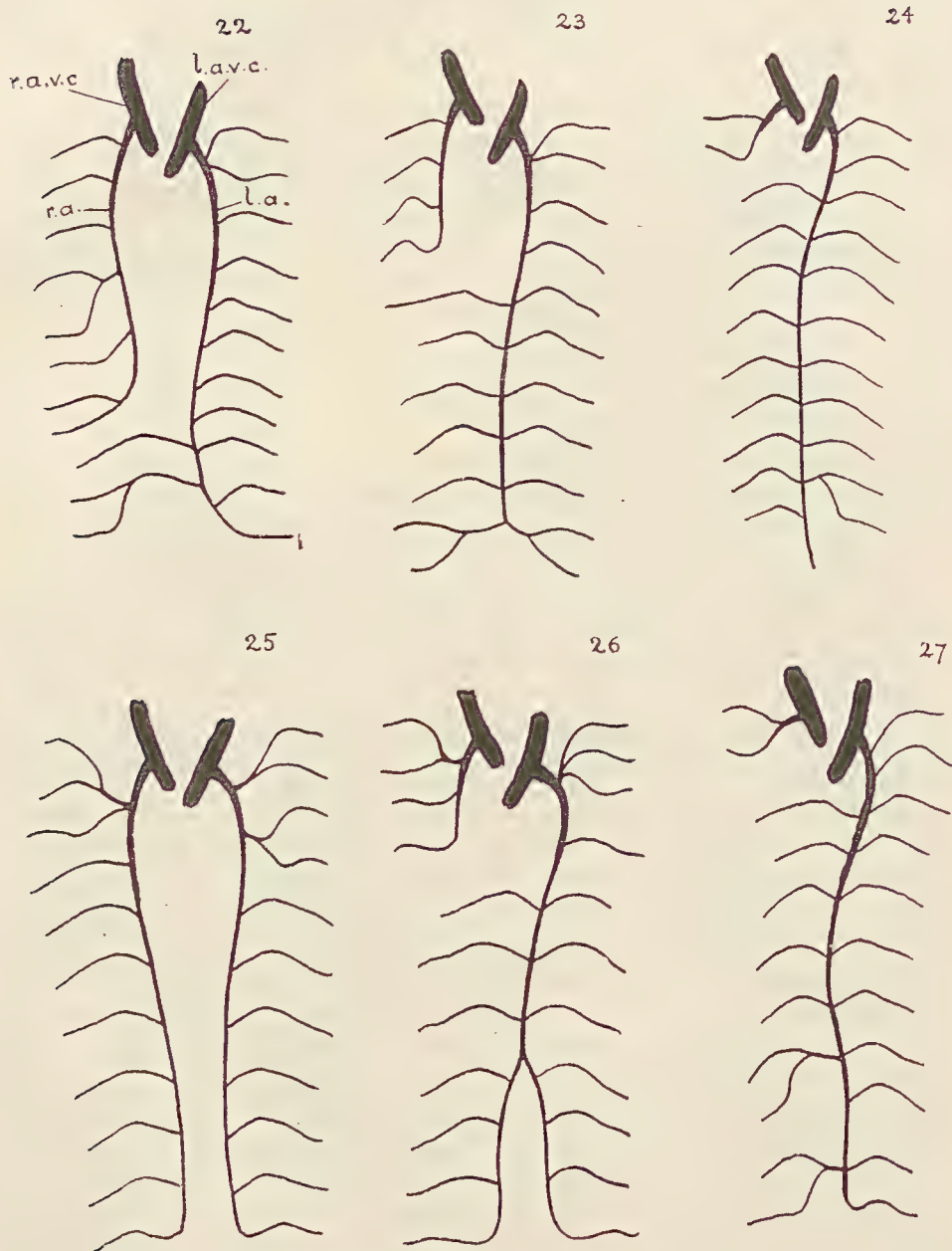
4. Right Azygos well developed. Left Azygos with few intercostals

This is a rare and exceptional condition in the Marsupials. It has been recorded by Cunningham (1882) in *Thylacinus* and by Parsons (1896) and Beddard (1895, 1907) in some of the Macropodinae. I have found it in *Thylogale billardieri* (Fig. 20).

It is clear from the above lists that there is considerable variability in the disposition of the azygos system in the Marsupials. Not only do related species show differences, but even within the limits of a single species there may be almost every type of arrangement. For example, in *Dasyurus viverrinus* Beddard (1907) has given a case which had equal right and left azygos veins, and in the course of the present investigation dissections of this species have shown that usually the left azygos predominates and that the right azygos may vary from having two intercostal veins to as many as eight (Figs. 22, 23, 24). Cunningham (1882) and Beddard (1907) have recorded instances in which the right azygos was entirely wanting in this species. Again in *Sarcophilus* I have found a considerable variation in the arrangement of the azygos system from two complete azygos veins to a condition in which the right azygos vein is reduced and receives only two intercostal veins while the left azygos is predominant (Figs 25, 26, 27). In *Thylacinus* there appears to be considerable variation as Cunningham (1882) found the left azygos absent. On the other hand Beddard (1907) stated that the left azygos predominates and the right azygos supplies only four intercostal spaces.

Having regard to this wide range of variability it would be unwise to attach too much importance to the azygos system as a basis of classification or as a means of indicating relationships. Beddard (1907) was inclined to regard this system as indicating relationships and affinities though he added the qualification that this indication was given only in a general way.

The condition in which both azygos veins are equally well developed may be regarded as primitive, nevertheless *Didelphys*, which, according to Bensley (1903) represents the nearest living approach to a primitive marsupial type, shows



VARIATION IN THE ARRANGEMENT OF THE AZYGOS SYSTEM

FIGS. 22-24—*Dasyurus viverrinus*; FIGS. 25-27—*Sarcophilus harrisii*.

(The lettering in fig. 22 applies to all six figures. References as in figs. 17-20.)

a very highly specialized condition in usually having no vestige of the right azygos. On the other hand, the wombat and some of the kangaroos sometimes show the primitive arrangement, though these animals are regarded as being highly specialized marsupials. A careful examination of McClure's and Beddard's lists, together with those cases which are given in the present paper, shows that the azygos veins in the marsupials give no reliable indication of the affinities of the various members of the order. I cannot agree, therefore, with Beddard (1907. p. 219) when he says that 'the division of the marsupials into Diprotodont and Polyprotodont is justified by the condition of the azygos veins,' and I do not think there is much in his contention that 'in the Diprotodont division there is a much greater tendency for the two azygos veins to persist than among the Polyprotodonts'. As I have shown above *Sarcophilus* and *Dasyurus* (both Polyprotodonts) show all stages between a complete double system of azygos veins and a predominant left azygos vein. The fact is that in the Marsupialia the azygos system is of little value in determining relationships.

McClure (1903) was of opinion that the single azygos is the rule in marsupials and that when the right and left are present this condition may be regarded as a variation. My own investigations do not confirm this. On the contrary I consider that the double azygos is typical of the marsupials, though frequently one, generally the left, is much more highly developed than the other, as for example, in *Trichosurus vulpecula fuliginosus* where the right azygos is very small and receives blood from only three intercostal spaces, or in *Thylogale billardieri* where the right azygos predominates. Milne-Edwards and Owen erred in the opposite direction in stating that the two azygos veins in the marsupials were equally developed and symmetrical.

Our present knowledge of the arrangement of the azygos system in the Marsupials may be stated as follows—normally, right and left azygos veins are present, usually, however, one is larger than the other, and in such cases it is more common to find the left azygos vein the predominant one. The arrangement of the azygos system is not always constant even within the limits of a single species, and a comparison of the arrangement of this system in different species of marsupials rarely helps in assessing the relationships of the members of the group.

5. The Posterior Veins.

The posterior vena cava receives the blood from the posterior region of the body and alimentary canal, and returns it to the right auricle. As in the higher mammals the veins from the alimentary canal unite into the hepatic portal vein which breaks up in the liver. From the liver the blood is collected by the hepatic veins which enter the posterior vena cava.

Posterior to this the posterior vena cava receives blood from the hind limbs, the pelvic region, the reproductive organs, kidneys and lumbar region. It is important to note that the marsupials differ from the higher mammals in the manner in which the posterior vena cava lies completely ventral to the aorta. The only exception to this rule would appear to be *Schoinobates volans* (= *Petaurus taguanoides*) in which, according to Hochstetter, the aorta lies ventral to the posterior vena cava as is the case in the higher mammalia.

Beddard (1909) has discussed at some length the arrangement of the spermatic (or ovarian) veins in Marsupials which show considerable variation. The essential arrangement is shown in *Thylogale* (Fig. 28) and *Sarcophilus* (Fig. 31) where the ovarian vein from each ovary receives the uterine vein. About the level of the beginning of the posterior vena cava each ovarian vein divides into an

inner posterior ovarian vein, which joins the posterior vena cava with its fellow from the other side, and an outer anterior ovarian vein which enters the renal vein.

McClure (1903) has dealt very fully with the numerous variations which are to be found in the arrangement of the posterior tributaries of the posterior vena cava in *Didelphys*.

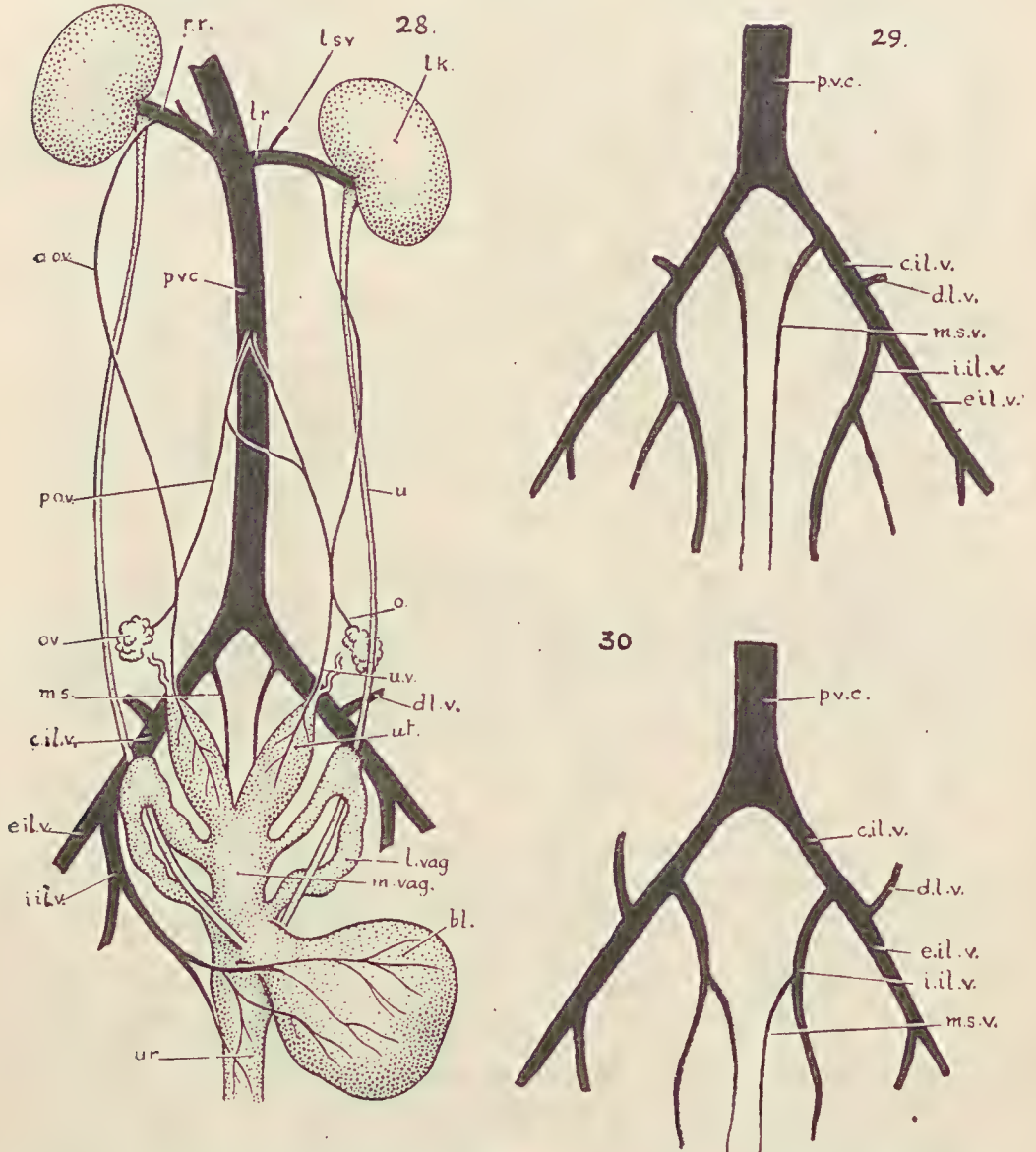


FIG. 28—*Thylogale billardieri*. Veins of the urogenital system connected with the posterior vena cava. FIG. 29—*Dasyurus viverrinus*. Posterior veins. FIG. 30—*Phascologomys ursinus*. Posterior veins. a.o., anterior ovarian vein; bl., bladder; cil.v., common iliac vein; d.l.v., dorso-lumbar vein; e.il.v., external iliac vein; i.il.v., internal iliac vein; l.k., left kidney; l.r.v., left renal vein; l.s.v., left supra-renal vein; l.vag., lateral vaginal canal; m.s.v., median sacral vein; m.vag., median vagina; o., ovarian vein; ov., ovary; p.o., posterior ovarian vein; p.v.c., posterior vena cava; r.r.v., right renal vein; u., ureter; ur., urethra; u.t., uterus, u.v., uterine vein.

In the course of the present investigation it has been found that there are two main plans upon which the affluents of the posterior vena cava are formed.

(1) The internal Iliac Veins remain distinct from the Median Sacral (Caudal) Veins

This condition is found in *Thylagale billardieri* (Fig. 28), *Sarcophilus harrisi* (Fig. 31), *Perameles gunnii*, and *Dasyurus viverrinus*.

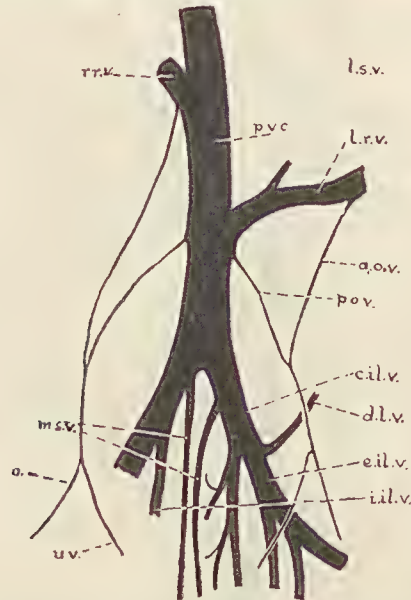


FIG. 31—*Sarcophilus harrisi*—posterior vena cava and its branches.

(References as in figs. 28-30.)

In this type the two median sacral-veins start in the tail and run along the ventral side of the sacrum, one on each side of the median sacral artery and finally open into the common iliac vein. Each internal iliac vein returning blood from the bladder and pelvic region joins with the external iliac (femoral) vein of its own side to form the common iliac vein which joins with a similar vein of the opposite side to form the posterior vena cava (Fig. 29).

(2) The Median Sacral Veins join the Internal Iliacs

This condition is found in *Phascalomys ursinus* and *Trichosurus vulpecula fuliginosus*.

Here the two median sacral veins run forward on either side of the median sacral artery and each opens into the internal iliac vein of its own side. The internal iliac vein then joins the external iliac vein to form the common iliac vein. The two common iliac veins unite to form the posterior vena cava (Fig. 30).

If the posterior veins are as variable in other marsupials as they are in *Didelphys* it is not likely that the two types given above may be found in the same species.

SUMMARY

One of the objects of the investigation was to ascertain if the arrangement of the blood system in the Marsupialia threw any light upon the vexed question of the relationships of the major divisions of the group as well as upon the affinities of the group as a whole.

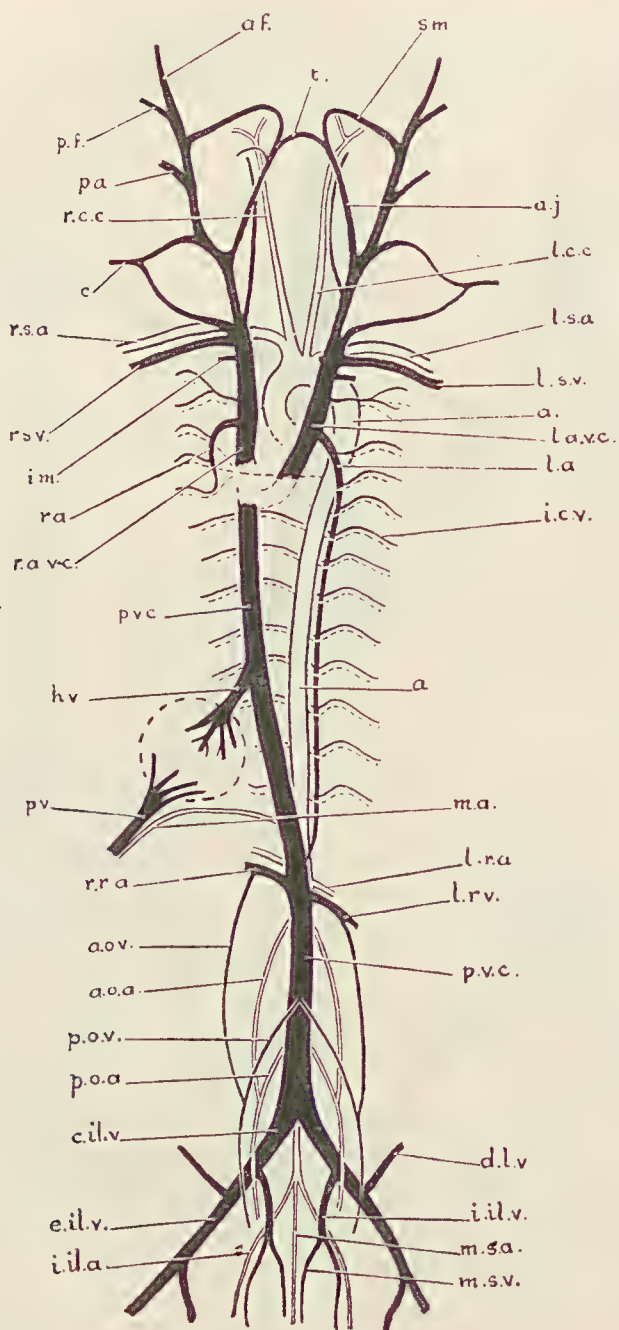


FIG. 32—Generalized diagram of blood system of a marsupial. (The veins are shown black, the arteries as double lines. The intercostal arteries are shown as dotted lines.)

h.v. = hepatic vein; *p.v.* = portal vein; *l.c.v.* = intercostal vein.

(Other references as in previous figures.)

Parsons (1902) has analyzed the arrangement of the branches of the aortic arch throughout the Mammalia and has shown that it is very variable, and, further, has made it clear that no specific arrangement characterizes any particular Order of Mammals. This same variability is to be seen within the Marsupialia which, incidentally, contains all the variations instanced by Parsons for the whole of the Mammalia.

With one exception (*Petaurus breviceps*) the marsupials retain the right and left anterior venae cavae derived from the primitive anterior cardinal veins, a character which they share with many Monodelphids.

Beddard (1907) made a comprehensive analysis of the azygos system in the Mammalia in which the system shows considerable variation. McClure (1903), Beddard (1907), and the present writer have shown that this system is very variable within the Marsupialia and in the present paper evidence has been submitted to show that considerable variation may exist even within the limits of a single species. Broadly speaking, the marsupial azygos system may be regarded as being more primitive than that of the higher mammals, because it shows more consistently than in the latter the presence of the primitive right and left branches, though usually the left is more highly developed than the right. Occasionally one side may be missing altogether, but I regard this as being abnormal.

The analysis given in this paper makes it clear that the blood system of the marsupials differs in no fundamental respect from that of the Monodelphia, where considerable variation is to be found.

For what it is worth the evidence of the marsupial blood system points to the fact that the Didelphia and Monodelphia have arisen from a common stock in which there were two anterior venae cavae and two azygos veins.

With the exception of Fig. 1 all the illustrations are original and were redrawn for publication by Capt. D. Colbron Pearse of the Tasmanian Museum and Art Gallery.

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Record of *Glossopteris* from Cygnet

By

A. N. LEWIS, LL.D.

PLATE XIII

(Read 13th November, 1939)

Plate XIII is a photograph of a small frond of *Glossopteris* from the Cygnet coal measures, recorded as confirming R. M. Johnston's observations.

These coal measures have been described by Johnston (1888), Twelvetrees (1902) and Reid (1922). Johnston records *Vertebraria* and 'a dwarf form of *Gangamopteris* probably identical with *G. spathulata* (M'Coy)'. In Plate X figures 4-8 he illustrates specimens from Adventure Bay.

On several occasions I have made as thorough a search as possible for fossils in the Cygnet coal seams without identifiable result except for fragments of *Vertebraria*. The fossil here indicated was found at 'Heaney's Mine' (Reid, 1922, p. 145) about 2 inches below the floor of the coal seam.

From the examination in the field I feel much doubt whether these coal measures should not be grouped with the Springs sandstone series rather than with the permian marine mudstones. Rocks of the Fern Tree stage underlie the coal measures but the marine series ends regularly and abruptly. The coal measures appear to me to be the base of the Springs sandstones as developed in the area and to merge gently upwards into this series. The stratigraphical break occurs at the top of the marine mudstones, not at the top of the coal measures.

The finding of this fossil, therefore, becomes of great interest. It has been submitted to Dr. A. B. Walkom who pronounces it to be definitely a *Glossopteris* but unfortunately not sufficiently well preserved to be certain of its species. It appears to me to be identical with Johnston's *Gangamopteris* from Adventure Bay. A fragment of *Vertebraria* occurs in the same piece of rock (at right angles to the bedding planes) and a section is discernible just above the leaf in the plate accompanying this paper. It is generally accepted that the Adventure Bay and Cygnet coal measures are as similar as those isolated coal basins ever are (see Johnston 1888 pp. 142-144). I consider that these coal measures should be regarded as forming the base or, in time, the earliest phase of the freshwater sandstone series.

Johnston's determination of *Gangamopteris spathulata* (M'Coy) should be corrected to *Glossopteris* sp. Both this fossil and Johnston's discoveries are small forms. Their prevalence over two separated areas leads to the impression that these are a dwarf or decadent form and not merely small specimens. It would be wrong to group them with *Gangamopteris spathulata* (M'Coy) as this is probably quite a distinct plant which Johnston, working on poorer material, has confused.

The fossil in question and, hence, Johnston's *Gangamopteris spathulata* (M'Coy), can only be called *Glossopteris* sp. until a specimen sufficiently well preserved for description is found.

It appears that the *Glossopteris* flora, in a decadent phase, persisted to the time of or immediately preceding the deposition of the Springs sandstone. No marked time interval between this and the Fern Tree stage of the Upper Permian Marine Mudstone is discernible here or elsewhere in Southern Tasmania. Only a little higher (some 700 feet) in the Springs Sandstones are found terrestrial fossils assigned to Upper Triassic (Rhaetic) age (Walkom 1926, p. 68). Only a little lower (again some 700 feet), shell fossils assigned to the Upper Permian are to be found. The Fern Tree stage and Springs stage averaging some 1400-1500 feet in thickness represent in Tasmania the time interval between the Upper Permian and the Upper Triassic, and no material disconformity has been discovered in the series. It appears therefore that the inclusion of this dwarf form of *Glossopteris* is hardly sufficient to assign these coal measures definitely to a Permian age and, on the other hand, the base, at least, of the Ross sandstones should probably be dated as very low in the Triassic. A considerable time interval covered by the series mentioned is evident and much resorting on a very stable terrain is indicated.

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Glossopteris sp. from Cygnet. Natural size.

NATIONAL MUSEUM OF VICTORIA

The Vegetation of Mt. Wellington, Tasmania The Plant Communities and a Census of the Plants

By

D. MARTIN, B.Sc.

PLATES XIV, XV, XVI

(Read 13th November, 1939)

INTRODUCTION

In this paper a description is given of the vegetation of an area approximately five miles square (approx. Lat. $42^{\circ} 54'$; Long. $147^{\circ} 17'$) lying west of Hobart and including all the Mt. Wellington Park Reserve and part of the Hobart City Water Reserve. These have been resumed since 1906, but before that time were commercially exploited and all the millable timber removed from the lower slopes. Since the creation of these reserves there has been some regeneration, but owing to frequent and often devastating bush fires the original appearance of much of the vegetation has been changed considerably. However, the higher parts are sufficiently untouched and the original composition of the lower parts clear enough to present a picture of the relationships between the various communities.

The plant cover of this area is practically pure *Eucalyptus* forest formation, covering a vertical range from sea level to 4000 feet. It gives an opportunity of studying the relation of the *Eucalyptus* forest formation to altitude and climatic and edaphic factors towards the most southerly part of its distribution. The relative dryness of the area has prevented the development of sub-antarctic rain forest and has modified the Austral-Montane formation considerably. A study of this region therefore forms a preliminary step in the study of these formations in Tasmania and helps to extend southwards the study of the montane vegetation of eastern Australia begun by Brough, McLuckie and Petrie (1924) at Mt. Wilson, McLuckie and Petrie (1927) at Kosciusko and Fraser and Vickery (1937-9) at Barrington Tops. Within Tasmania a comparison with the vegetation of Cradle Mt., where conditions are colder and wetter than at Mt. Wellington, can be made and the descriptions of the latter area by Gibbs (1920) and Beadle (1935) extended.

Physiography. (See Map.) The area forms the eastern end of an E-W range about 20 miles long, which rises to 4000 ft. in several places and forms the watershed between the lower courses of the Derwent and Huon Rivers. It is separated from the Mt. Humboldt mass by the valley of the Russell Falls River, which is in turn separated from the central plateau by the valley of the Florentine and Derwent.

The topography is simple, being the eastern and almost square end of the range, rising fairly evenly with increasing gradient, the final 400 ft. at an angle of 30 degrees. In one part the edge of the sill capping the plateau has broken away to form cliffs ('Organ Pipes') about 300 ft. high of the columnar dolerite. The top of the range is almost flat, sloping gradually to the west, with a consistent slope of 9 deg., and falling 200 ft. in about half a mile. There is then a sudden drop of about 30 ft. to a flat swampy plain of glacial origin, at the head of the North-west Bay River. On the western side of these swamps, a steep North-South dolerite ridge (Mt. Arthur) rises to 4100 ft. The northern and eastern sides of the range are drained by small creeks, while the whole of the top drains into the swamps and thence to the N.W. Bay River. This flows south, descending rapidly in a series of cascades, then turning south-east at approx. 1500 ft. through the foothills to the D'Entrecasteaux Channel.

Geology.—For the most part, the plateau is capped by a Jurassic (?) dolerite sill about 1600 ft. thick, overlying Triassic sandstones of about 800 ft. depth, resting on an Upper Permian base.

In many places the edges of the dolerite sill have broken away and descended as extensive talus slopes, which have covered over the sandstone, except in isolated places on the shoulders of spurs and in some cases have descended further and covered over mudstones as far down as the 700 ft. contour. Smaller dolerite masses at lower levels are found in the foothills, notably at Neika, Chimney Pot Hill and Mt. Nelson. These are sometimes lower sills intrusive into Permian strata and sometimes the results of block faulting of the main plateau mass.

These talus slopes have an important effect on the vegetation, providing a well drained rocky soil with no surface water. Drainage from above flows through and under this talus to appear when the mudstone and sandstone protrude from beneath. This type of physiography, summit cap of dolerite with talus covering sandstones and mudstones, is characteristic of most of the mountains in the eastern two-thirds of Tasmania and is thus an important ecological feature. The initial stages of a xerosere has formed on this talus slope, which has been colonized except for unstabilized patches (locally called 'Ploughed Fields or Potato Fields'). Serious bush fires and consequent erosion on the south slopes have removed plant and soil covering, and parts have reverted to the open talus which, is being recolonized slowly.

The summit of the plateau shows evidences of glaciation, the area 'Dead Island' being an example of a 'nunatak'.

Soils.—The soils of Mt. Wellington fall into two broad groups, the High Moor and Skeletal soils of the plateau and upper slopes and the podsols below the 2500 ft. contour. In flat to gently sloping sites where they are fully developed, the high moor soils consist of between two to three feet of fine black peat with some coarser organic remains in the top few inches, overlying a stony and clayey horizon of deposition and weathering. There is rarely any evidence of a well-marked horizon of deposition alone. In localities which vary from relatively gentle slopes to cliffs and where the natural erosion process is faster than the weathering process, extensive areas of exposed rock in boulders and sheet rock occur. Frequently some soil and organic material is lodged in cracks and crevices in this rocky terrain. Where the erosion and weathering process are in the balance, areas of skeletal soils occur. These consist of shallow stony, clayey soils with little or no accumulation of organic matter and frequently containing large boulders.

The podsols of the lower slopes consist of dark grey and sandy loams with much organic matter above a more or less distinct bleached horizon, which in turn overlies

yellow and grey clays. In areas of somewhat restricted drainage there is a greater accumulation of organic matter, with the result that the soil approaches a peaty sand and directly overlies the clay subsoil.

On the flat tops of the sandstone layers not covered by the talus, acid swamps have developed in some parts consisting of black peaty sand over yellow clay. These are shallow and subject to drying out, and so do not support the Button Grass (*Gymnoschoenus adjutus* Nees.) swamp characteristic of the permanently wet type of acid swamp in the west and south.

Climate. (Information supplied by the Divisional Meteorologist, Hobart.)
Rainfall.—The mean annual rainfall varies from 23·97 inches to nearly 60 inches on Mt. Wellington. (See Table I).

TABLE I

Place	Alt. ft.	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Mean
Hobart ..	177	1·84	1·49	1·73	1·97	1·85	2·21	2·13	1·83	2·07	2·33	2·43	2·09	23·97
Waterworks	527	2·62	2·01	2·75	3·14	2·47	2·98	2·90	2·30	2·89	3·67	2·65	3·15	33·53
Ferntree ..	1300	4·44	3·62	4·20	4·90	3·94	4·64	4·59	4·17	4·55	5·86	4·74	5·51	55·16
Springs ..	2403	4·48	3·35	4·76	5·47	4·43	5·24	4·74	4·22	4·89	5·72	2·77	5·51	57·58
Gap ..	4000	4·04	3·36	4·53	5·43	4·04	4·62	4·18	3·52	4·83	6·04	4·95	5·81	55·35

With distance from the mountain, the rainfall decreases rapidly almost independently of altitude, but on the mountain the 1200 contour corresponds approximately with the 50" isohyet. The seasonal variation in monthly rainfall is not pronounced. At Hobart a mean minimum of 149 points occurs in February, monthly averages gradually increase to 243 points in November, but a slightly secondary minimum is shown in August. There is, however, a marked fluctuation at irregular intervals, the lowest total in one month ranging from 0·03 (January) to 0·39 (September) and the highest total 5·91 (January) to 10·16 (August). Droughts occur. Southern Ocean depressions are responsible for 50 per cent of the rainfall. The rain is gentle; on 70 per cent of the days of rain the amounts are less than 15 points. Heavy falls of over an inch in 24 hours are of comparatively rare occurrence. Local variation is considerable.

In addition to the rain, the mountain above 1300 ft. is often mist-covered as the result of easterly weather, and in the summer the afternoon sea breeze often produces a bank of cloud on the South-east face. In conjunction with other factors this has an important effect on the vegetation.

Temperature.—The average monthly maximum and minimum temperatures for Hobart and the Springs are given in Table II (below).

TABLE II

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Mean
Hobart ..	71·0	71·1	67·9	62·5	57·4	52·7	52·1	55·1	58·8	62·6	65·8	79·0	62·2
	52·8	53·4	50·9	47·7	43·9	41·0	39·6	41·1	43·3	45·6	48·3	51·2	46·6
Springs ..	60·0	61·7	57·8	52·4	48·4	44·8	43·9	45·3	49·0	52·2	55·6	58·1	52·4
	44·1	45·7	43·7	40·6	38·2	35·9	34·9	35·3	36·4	38·0	40·0	42·7	39·6

In Hobart the absolute highest temperature was 105·2° F. and absolute lowest 27·7° F.

Table III gives the average hours of sunshine per month for Hobart.

TABLE III

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
233.9	194.2	198.2	142.7	142.1	118.2	128.5	159.1	173.1	191.3	220.0	217.0	2118.3

The mean amount of cloud per month (on a scale 0-10) is very even, ranging from 5.8-6.4. The mean monthly humidity for Hobart ranges from 58-80 per cent and for the Springs 70-77. There is considerable wind action in Hobart. Gusts of over 60 m.p.h. may be experienced in any month, and the mean total miles in 24 hours ranges from 150-160 per month. This must be more severe at higher levels, especially on the plateau.

Snow may fall on the mountain in any month, but rarely lies more than a few days at altitudes below 2400 ft. Table IV gives average number of days of snow fall.

TABLE IV

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
0.3	0.2	1.0	1.8	2.7	3.9	4.0	4.6	3.2	2.4	1.7	0.5	26.3

Above 3000 ft. it may lie for weeks at a time during the months from May to September, and at 4000 ft. large areas may be covered continuously during that time and isolated drifts may last into November. Frosts occur down to sea level in open areas in winter months, but forest cover prevents their formation below 1500 ft.

Exposure.—The top and west sides of the summit of Mt. Wellington and the Mt. Arthur ridge and the N.W. sides of the range and its foothills receive maximum sunlight and experience maximum evaporation. The summit ridges experience also lowest temperature and maximum wind. The steep eastern face loses direct sunlight before mid-day in winter, while the shadow of the mountain covers most of the S.E. slopes early in the afternoon. The south face receives little direct sunlight except in summer.

STRUCTURE OF THE PLANT FORMATIONS

Two main formations exist in this area, one including a very reduced third type:

1. *Eucalyptus forest formation.*—This covers the greater part of the area, and varies from open forest of the lower slopes and foothills to dense *E. regnans* forests. Within this formation several sheltered gullies support a 'gully flora' of a subantarctic rain forest type called 'mixed forest of the West Coast,' by Gibbs (1920), analogous to the 'gully flora' of tropical rain forest origin occurring in the *Eucalyptus* formation on the Hawkesbury sandstones (Pidgeon, 1938).
2. *Austral-Montane Formation* (Gibbs, 1920).—This occupies an area of very limited extent on the summit of the range, and is restricted both in area and composition by the relative dryness and warmth of the situation compared with that on mountains further inland where a fuller development obtains. Shrubberies of alpine conifers, dwarf *Arthrotaxis* forests, *Nothofagus* shrubberies and plant mosaics are absent.

The sides of the plateau, except the top of the steep eastern face, are occupied by *Eucalyptus* forest formation. On the summit all places with sufficient depth of soil and drainage and which are not exposed to the full force of the wind, also support stunted *Eucalyptus coccifera* forest. Elsewhere on the summit the fairly well-drained but shallow soils support the reduced Austral-Montane formation, while the poorly drained area is occupied by swamps analagous to those of Barrington Tops (Fraser and Vickery, 1937-39) and Kosciusko (McLuckie and Petrie, 1927). Exposed rock surface occurs in many places, mainly unstabilized dolerite talus. The initial stages of a xerosere are to be found here, as the slopes are being colonized slowly by the shrubs from the *E. coccifera* and *E. coccifera-urnigera* associations.

THE EUCALYPTUS FORESTS

(1) *E. coccifera* Consociation

These species form a pure consociation between 3600 and 4000 ft. It occupies the rocky soils and stabilized boulder masses, and is limited in its distribution by three main factors:

(a) *Drainage and water supply*, which restricts the distribution of the consociation to the steeper and rockier parts, where there is adequate drainage and aeration, but which receive a good supply of water from higher levels. The effects of this factor are everywhere apparent. All slopes of approx. 10-30 degrees with a reasonable supply carry the consociation. The lesser slopes and very shallow soils support the grassland and shrub communities, and the poorly drained areas the swamps. The relation to drainage and water supply is strikingly demonstrated by 'Dead Island'. This is a 'nunatak' within the swamps and rising a few feet above the water table, thus providing sufficient aeration and permanent water for the consociation to develop as an 'island' of eucalypt within the swamp.

Within the consociation where drainage fails or the water supply is inadequate, it is sharply replaced by patches of swamp associes such as mats of *Astelia*, *Gleichenia dicarpa*-*Baeckia Gunniana* mixtures or by grassland and shrub communities. The relationship between forest and swamp is comparable to that described for *E. pauciflora* on Barrington Tops and Kosciusko.

(b) *Exposure*.—Though low temperature may have some effect on the distribution of *E. coccifera*, it seems more probable that the higher transpiration coupled with a rapidly draining and drying soil prevent its establishment on the top of the plateau and high up on the ridges. Exposure reduces the size of the species from trees 15 ft. high and 18 in. thick to prostrate shrubs a few inches high with permanently juvenile foliage at practically the same altitude.

(c) *Competition*.—On the side of the plateau the lower limit of the species is determined by competition, mainly with *E. urnigera*, which begins to appear at 3600 ft. Below this level to 3000 ft. the balance is a delicate one and determined by local climatic variation and power of regeneration from fire. *E. coccifera* is more drought and cold resistant than *E. urnigera*. It is unhurt by long periods under snow or even colder conditions, when the foliage is covered with thick masses of ice for a period of days. (An exceptionally long period of icing about 15 years ago killed off large areas of the *E. coccifera* consociation, however.) Though *E. urnigera* is less frost and drought resistant, it regenerates better and grows faster, so that mild winters and fires favour its spread at the expense of the other species. Dense stands of *E. urnigera* saplings occur in many places in the more sheltered and lower parts of the *E. coccifera-urnigera* association, with logs and occasionally large living trees of *E. coccifera* within them, indicating an active extension of the *E. urnigera* component.

The *E. coccifera* consociation (assisted by the rocky nature of the ground) is fairly open in most places, permitting the development of an important shrub stratum. This comprises members of the reduced Austral-Montane association adjoining with the exception of extreme heliophilous and swamp types. In the more sheltered and wetter portions it includes shade and moisture loving species from the lower associations such as *Bauera rubiodes*, *Nothogagus Cunninghami* (shrub form) and *Leptospermum lanigerum*.

The *E. coccifera* consociation is of common occurrence on Tasmanian mountains in the eastern half of the island. It forms with *E. vernicosa* the advance margin of the Eucalypt into the remnants of the Austral-Montane, which survives where cold exposure, shallow soils and long periods under snow halt the more vigorous tree invader.

(2) *E. coccifera*-*urnigera* Association

Below 3600 ft. on the outer slopes of the plateau, *E. urnigera* is associated with other Eucalypt species. It does not form pure stands except as consociates of saplings (see above). At the upper limit of its distribution it becomes less frequent until pure *E. coccifera* is found, and on the lower limit it cannot compete with *E. gigantea* and *E. regnans*.

It is confined to stabilized dolerite talus in those parts where good drainage, continuous water supply and shelter from drying winds obtain. Where drainage is poor and conditions are swampy, the species is dwarfed to a shrub and may never develop adult foliage. It is also very scanty on steep slopes where the soils drain out quickly or where the trees are exposed to insolation and drying winds. In such places *E. coccifera* continues in a nearly pure state down to the *E. gigantea* community.

The shrub layer presents a rich and varied facies as a result of the warmer conditions, shelter, the plentiful supply of water draining from above combined with the effects of the open canopy. The more heliophilous types of the summit plateau cannot compete, and are replaced by more mesomorphic species, e.g., *Orites acicularis* and *O. revoluta* are replaced by *O. diversifolia* and *Richea Gunnii* and *R. scorparia* by *R. dracophylla*. *Bauera rubiodes*, *Leptospermum lanigerum* and *Telopea truncata* reach their maximum development in the wetter parts. On the other hand shrubs such as *Gaultheria hispida*, *Cyathodes glauca*, *Prostanthera lasiantha*, *Gahnia psittacorum*, *Hakea macrocarpa*, *Olearia viscosa*, *Correa* spp, *Bedfordia salicina* and *Pleopeltis diversifolia* (Fillices) are at the upper limit of their distribution. The shrub layer is the most varied of any of the associations, containing many elements from the *E. coccifera* and summit plateau associations from above and the *E. obliqua-regnans* association from below. *E. Johnstoni* is common towards the lower levels of the association.

An interesting feature of this association at lower levels is the colonization of sheltered patches of open talus by the fern *Pleopeltis diversifolia*, whose tough rhizomes twine among the boulders and help the accumulation of soil and humus.

At levels below about 2500 ft. *E. urnigera* cannot compete with *E. gigantea* and *E. regnans* and is quickly displaced.

(3) *E. obliqua*-*regnans* Association (800 ft.-2500 feet)

This association is not a very intimate one and varies within wide limits in its composition according to differences in local climate. On the upper limit, *E. gigantea* may largely or completely replace *E. obliqua*, and one might be justified in defining an association on Mt. Wellington with the former as the important element representing the extensive *E. gigantea* associations found in other parts

of the island. However, until these have been studied and defined, these *E. gigantea* communities have been included as an element of the *E. obliqua-regnans*.

At its lower level, *E. obliqua* passes into the open forests of the drought resistant species (*E. obliqua*, *E. tasmanica*, *E. viminalis*, *E. salicifolia*, *E. linearis*) characteristic of the foothills below 1000 ft.

According to aspect, moisture supply and exposure, either *E. obliqua* or *E. regnans* may become locally dominant or form pure stands. Where specialized conditions prevail specialized communities have developed (gully communities, sandstone communities). *E. urnigera*, *E. Johnstoni* and *E. globulus* also occur.

This association is the most important type of commercial forest in S.E. Tasmania. For this reason and also because of bush fires it exists in greatly reduced form in the area studied.

Dealing with the two most important species separately:—

E. obliqua

This species has wider distribution in the association, and is found in all parts of the forest, and often forms pure societies on the drier places, such as the tops and western sides of the ridges. It becomes attenuate towards the wetter parts, where it is replaced by *E. regnans* and by *E. gigantea* at high altitudes. It occurs into the open forest association as an important element.

Where this species is dominant the canopy is fairly open, and an important tall shrub layer of a relatively xerophytic type develops with *Acacia verniciflua*, *Eriostemon squameus*, *Ozothamnus rosmarinifolius*, *Pultenea juniperina*, *P. daphnoides*, *Monotoca lineata* and *Oxylobium ellipticum* as important characteristics. Frequent fires and consequent denudation have greatly reduced the tall shrub layer in many parts, but there is no doubt that it was an important element in the climax community, and replacement of the older trees was dependent on quick germination and growth in temporary clearings.

E. regnans

From the drier tops and exposed N.W. sides of the ridges towards the shadier S.E. sides, *E. obliqua* is replaced by *E. regnans*. Here the tall shrub layer is also well developed, but presents a more mesomorphic appearance. *Olearia argophylla*, *Pomaderris apetala*, *Bedfordia salicina*, *Acacia dealbata*, *Zieria Smithii*, *Prostanthera lasiantha*, *Gahnia psittacorum*, *Pittosporum bicolor*, etc., displace the types dominant with *E. obliqua*. There is no low shrub or herb layer (except ferns) in the denser parts, but occasional more open parts support shrubs such as *Gaultheria hispida*, *Drimys lanceolata*, *Correa Lawrenciana*, *Olearia myrsinoides*, *O. stellulata*, *Aristotelia peduncularis*. Ferns such as *Polystichum aculeatum*, *Blechnum capense*, *Histopteris incisa*, *Pleopeltis diversifolia*, etc., occur.

In the wettest parts *Olearia argophylla* dominates the shrub layer and has a canopy of leaves about 15 ft. above the ground, supported by a mass of bare stems about 3 inches thick. Only such ferns as *Dicksonia antarctica*, *Polystichum aculeatum*, *Blechnum* sp. and *Pleopeltis diversifolia* develop on the floor, and the structure approaches that of the lower parts of the 'gully flora', but with occasional *E. regnans* trees.

On the South-east side of the mountain *E. regnans* reached its maximum development, formerly having formed large societies of magnificent trees up to 200 ft. high. These were destroyed by fire in 1914, and subsequent erosion hindered regeneration in many parts. In others it is proceeding actively, and there are large areas of regrowth with the white skeletons of the previous forest rising above them. In these areas the canopy is denser and the shrub layer of less importance than in other parts of the association, but still well represented.

Replacement of the trees in the mature forest takes place in clearings made by falling trees or by fires. The Eucalypt seedlings cannot establish themselves beneath an undisturbed tall shrub layer. The bottoms of the gullies being always moist are never affected by fires, and the Eucalypt can never become established, and a 'gully flora' exists (see below).

Towards the lower levels, *E. regnans* is replaced by the *E. globulus* communities, which occupy the sheltered parts of the open forest association.

The following specialized communities occur in the association:—

(a) 'Gully Flora'

At the bottom of those gullies not exposed to the dry north-westerly winds, *E. regnans* cannot establish itself in the dense shrub layer, and a 'gully flora' exists.

At altitudes up to approx. 1500 ft. the dominants are *Olearia argophylla*, *Pomaderris apetala* and *Bedfordia salicina*, which form a canopy of leaves 15-20 ft. above the ground, supported by a thicket of bare stems approx. 3 inches in diameter, with occasional thicker ones of *Athernosperma moschata* and *Acacia dealbata*. The shaded ground can support no shrubs, and generally only ferns, stunted *Dicksonia antarctica*, *Polystichum aculeatum* and *Blechnum* spp. grow on the floor, while *Pleopeltis diversifolia* scrambles over fallen logs and thicker tree stems, and mosses and liverworts may occur on the thinner ones. The area close to the creek at the bottom of the gully is occupied by fern communities dominated by *Dicksonia antarctica* (up to 20 ft. high) and a rich fern, moss and liverwort ground flora. Light breaks, such as may be caused by neighbouring eucalypt trees falling into the gully, may be colonized by *Acacia dealbata*, and mature societies of this species, consisting of trees 9 in. thick, may be seen rising 10-20 ft. above the surrounding vegetation.

At higher altitudes the *Olearia* and *Pomaderris* are replaced by communities of *Nothofagus-Athernosperma* forest, which may be regarded as small areas of reduced microthermal rain forest (Herbert, 1935), existing where local conditions are suitable. They are related to the more extensive forests occurring at the upper reaches of the river valleys in the S.E. of Tasmania (Kermadie, Esperance, etc.), where a similar transition from *E. regnans* forests to *Nothofagus-Athernosperma* forests occurs on a larger scale.

In the gullies on Mt. Wellington the *Nothofagus* trees reach about 40 ft. in height, and the *Athernosperma* 20-30 ft., with occasional trees of *Acacia melanoxylon* and *Olearia argophylla*, *Bedfordia salicina* and *Pomaderris apetala* in the drier parts. Cold and lack of shelter limit the distribution of most of the 'gully' species to below approx. 2300 ft., with the exception of *Nothofagus* which protrudes into the Eucalypt forest at the heads of some of the gullies and reappears as the shrub form at higher altitudes in the *E. urnigera* and *E. coccifera* associations.

Light breaks in the upper 'gully' vegetation are colonized by *Nothofagus* seedlings and not by Eucalyptus from the surrounding forests, confirming observations on the vigour of this species under suitable moisture conditions made by Herbert (1936) and Fraser and Vickery (1937-39). The frequent periods of low humidity prevent its spread beyond the gullies, except as an occasional small tree in the *E. obliqua-regnans* or as the shrub form at higher altitudes.

(b) Sandstone communities

The triassic sandstones are exposed on the shoulders of the ridges, which protrude far enough from the main mass of the mountain to have been covered by the dolerite talus from above (2000-2400 ft.). In this acid sandy soil, which in

some places is poorly drained and swampy, communities are found which are different to the *E. obliqua-regnans* forests on the mudstone below and the *E. urnigera-coccifera* on the dolerite talus above.

The most striking feature is the dominance of *E. Johnstoni* which is of minor importance elsewhere, and the almost complete absence of *E. urnigera*. *E. Johnstoni* is of special systematic interest (Brett, 1938), and is confined to Mt. Wellington and a few other places in S.E. Tasmania where it is not common. It appears to some extent in the *E. urnigera-coccifera* association above, where it occupies a position similar to that of *E. subcrenulata* in similar associations in other parts of the island. It is very rare in the *E. obliqua-regnans* forest below.

At the Springs and White Rock, which are fairly well drained, the species attains the height of approx. 30 ft. Shrubs from the drier parts of the *E. obliqua* forest, such as *Monotoca lineata*, *Oxylobium ellipticum*, *Eriostemon squameus*, *Pultenea juniperina*, occur. In the more open parts, plants characteristic of sandy heaths, *Leptospermum scoparium*, *Epacris impressa*, *Richea sprengelioides*, *Banksia marginata*, etc., appear, and in the wetter parts *Gaultheria hispida*, *Bauera rubiodes* and *Richea dracophylla*.

At Snake Plains, which is badly drained, the facies is different again. On the north and west of the area the talus from the mountain above has rolled down onto the sandstone, while on the south it is buttressed by a small dolerite mass, and on the east it falls away in cliffs. The top of this sandstone platform is very flat except for small rocky outcrops a few feet high which support dwarf *E. Johnstoni* and the plants of the drier phase. The soil is shallow, and consists of practically pure black peat, supporting mainly a herbaceous vegetation of plants characteristic of acid sandy peaty soils, dwarfed *Gahnia psittacorum*, *Sprengelia incarnata*, *Restio australis*, *Hypolaena laterifolia*, *Richea sprengelioides* and dwarf *Melaleuca squamea*, etc. Where the soil is slightly deeper and better drained, dense thickets of myrtaceous shrubs, 6 ft. high (*Leptospermum scoparium* and *Melaleuca squamea*), exist with the harder plants of the drier phases such as *Monotoca lineata* and *Oxylobium ellipticum*. The small prostrate *Coprosma Moorei* is common on the bare peat. On the talus slope immediately above, the forest is regenerating following the fires of 1914, and dense stands of small trees of *E. Johnstoni* and *E. urnigera*, with an impenetrable mass of *Gahnia psittacorum* and *Bauera rubiodes*, spring from among the fallen logs of the old forest.

On the south side, the ecotone between the swampy plains on the top of the sandstone and the *E. obliqua-regnans* on the well-drained dolerite is very sharp.

(4) The Open Forests of the Lower Slopes and *E. globulus* Communities

These are outside the area studied, but a brief description is given to complete the picture.

The foothills consist of either mudstone or dolerite ridges. In the case of the first, the soil is shallow and impervious and the water quickly shed, and in the second the soil is subject to drying and cracking. Added to this the rainfall is low (25-30 in.). On the tops and north and west sides of these ridges, there is a stunted open forest of *E. linearis*, *E. salicifolia*, *E. viminalis*, *E. tasmanica*, with occasional *E. obliqua* and *E. globulus* where water conditions are better. The tall shrub layer is scanty or absent, but grasses and *Cyperaceae* and hardy low shrubs such as *Acacia stricta*, *A. vomeriformis*, *A. verticillata*, hardy *Epacridaceae* *Leguminosae* and *Rutaceae* occur.

On dolerite ridges, *E. linearis* often assumes dominance, and may form societies (Chimney-pot Hill), but generally the elements are mixed. In some cases the mudstone ridges have been so denuded of soil that only a stony clay remains,

supporting societies of *E. Risdoni* and its hybrid complex (Brett, 1938). The soil is too poor to support grass sward, and hardy small shrubs of *Epacridaceae* and *Leguminosae* fail to cover soil.

On the south and east sides of the ridges, the shade, shelter from the dry north-westerly winds and perhaps the effects of the moist sea breeze and the assistance given to the retention of water by the dip of the mudstone rock, form a marked local climatic contrast to the tops and west sides and have permitted the development of *E. obliqua-globulus* communities. These were formerly of great importance, but the value of the *E. globulus* and *obliqua* timbers led to their exploitation in the early days of the settlement. They now exist in reduced form only towards the heads of the gullies and isolated patches. Towards the top of the ridges, *E. obliqua* and *E. viminalis* predominate, but towards the bottom of the valleys *E. globulus* becomes increasingly important until it forms an almost pure society.

AUSTRAL-MONTANE FORMATION

This formation is very reduced and impure on Mt. Wellington, lacking many of the elements characteristic of other summit plateaux, where rainfall is more reliable and generally moister and colder conditions prevail. The conifers, *Arthrotaxis* spp., *Microcachrys tetragona*, *Phaerosphaera Hookeriana*, *Diselma Archeri* are absent, the only one present being *Podocarpus alpina*, and that does not form shrubberies. There are no dwarf mountain forest or herbaceous associations (Gibbs, 1920), with the exception of *Astelia alpina* communities. However, all the more xerophytic shrubs usually found in this formation are present, so the classification is retained. Three types of community are found:

(1) The Shrubberies

These occupy all the flat top of the mountain, except where the *E. coccifera* consociation and the swamp and grassland are found and the upper portion of the steep eastern face. It exists on the top by virtue of its capacity to endure wind and dry conditions too severe for *E. coccifera* and where there is too little soil and too many rocks for the *Poa caespitosa* grassland to compete.

On the upper portion of the steep eastern face, drainage and water supply are sufficient to support the *E. coccifera* consociation, but snow is blown off the flat top into deep drifts on this area and prevents its establishment. The low rounded shrubs of the formation can tolerate these conditions better than the *Eucalyptus* trees.

The vegetation takes the form of (a) rounded bushes 1-3 ft. high, such as *Orites acicularis*, *O. revoluta*, *Richea Gunnii*, *Richea scoparia*; (b) more upright bushes, 1-2 ft. high, such as *Ozothamnus ledifolius*, *Olearia ledifolia*, *O. pinifolia*, *O. persoonoides*, *Coprosma nitida*, *Drimys lanceolata*, etc.; (c) prostrate or creeping over boulders, e.g., *Leptospermum rupestre*, *Bauera rubioides*, *Exocarpus humifusa*, *Pentachondra pumila*, *Monotoca empetrifolia*, *Cyathodes dealbata*; (d) sub-erect mats to 1 ft. high, e.g., *Baeckea Gunniana*, *Cyathodes straminea*, *C. adscendens*, *Richea acerosa*, *R. sprengelioides*; and (e) herbs, e.g., *Astelia alpina*, *Poa caespitosa*, *Gleichenia dicarpa*, *Hypolaena laterifolia*, *Lycopodium* spp. and annuals. Only one 'bolster' plant (Sutton, 1929), *Abrotanella Fosterioides*, exists. Many of these shrubs occur in the *E. coccifera* consociation. Where the weathered rock has accumulated sufficiently to provide stretches of soil, the shrubberies are replaced by *Poa caespitosa* grassland, with scattered shrubs principally *Ozothamnus ledifolius* with *O. Hookeri*, *Orites acicularis* and *Richea Gunnii* less common.

(2) The Swamps at the Head of the North-west Bay River

Between the Mt. Wellington plateau and the Mt. Arthur ridge, there lies a shallow valley of glacial origin (3650-3800 ft.) about half a mile square. This receives all the drainage from the top of the mountain and a peaty swamp has developed. This is drained by the North-west Bay River which descends rapidly in cascades into the gorge between the Mt. Wellington mass and Mt. Montagu and the Thumbs. The river is very slowly cutting back into the swamp and a border of grassland at the farther edge indicates a succession.

Succession is so very slow that the area has probably remained unchanged over a long period, and the swamp may be regarded as relatively permanent. Succession of dry years have at times reduced the swamp and increased area of the grassland, shrubs and *E. coccifera*, which have been reduced again by the increase of the swamp in wet years.

One method by which the swamp and grassland developed can be observed on the higher areas in the small slowly moving streams flowing over the rock. A succession involving the 'bolster' plant *Abrotenella Fosterioides* can be traced. These plants colonize the edges and shallow waters, and by apical growth throw themselves into spreading mounds, which slow up and dam the flow. When about 3 ft. in diameter, the colony begins to die at the centre forming a bed for the establishment of *Hypolaena laterifolia*, *Baeckia Gunniana*, *Astelias alpina*, *Gleichenia dicarpa* and annuals, and if the drainage continues to be restricted the swamp associates develops. If, however, the stream breaks through and drains away in another direction, the succession tends towards the grass and shrub vegetation. In some places the periphery of mounds once up to 9 ft. in diameter can be traced in the swamp grassland ecotone.

The main part of the swamp consists of a dense mat of vegetation capable of supporting one's weight, the living portion being about 6 inches thick and deriving its firmness mainly from the stiff leaves of *Astelias alpina*. There is considerable local variation in composition, and, though the different successions have not been studied, they are probably as complex as those described for Kosciusko by McLuckie and Petrie (1927). The basis appears to be a mixture of *Astelias alpina*, *Gleichenia dicarpa* and *Restio australis*, with *Baeckia Gunniana* and *Hypolaena laterifolia* in the slightly drier parts. In places *Astelias alpina* may exist in a practically pure state, while in other intimate mixtures of *Astelias-Gleichenia*, *Baeckia-Gleichenia*, *Gleichenia-Hypolaena*, etc., exist. Quite frequently, *Richea scoparia*, *R. Gunnii*, *O. acicularis*, *Ozothamnus Hookeri* have managed to obtain a foothold, the large yellow bushes of *Orites acicularis* being particularly conspicuous.

Sphagnum occurs floating in the pools and as old mounds in the main body of the swamp, which are colonized by shrubs (chiefly *Richea scoparia*), and persist to a relatively late stage in the succession. It does not appear, however, that *Sphagnum* played an important part in the succession, and thus the swamps here are closer to those of Kosciusko than of Barrington Tops.

(3) Grassland

As the result of entranchment and drainage of the upper levels in the past, there is a succession to grassland. *Restio australis* is the first to disappear. *Astelias* and *Gleichenia* become less important, and *Hypolaena laterifolia*, *Carpas alpina* and *Baeckia Gunniana* become more important, and annual compositae, *Euphrasia collina*, *Gentiana dimensis*, etc., and shrubs appear. *Poa caespitosa* and the shrubs of the grassland *Ozothamnus* spp. and *Olearia* spp., *Monotoca empetrifolia*, *Epacris serpillifolia*, etc., increase in importance.

It is probable also that the grassland forms a subclimax on the top of the Mt. Wellington plateau, where the soils are too shallow and windswept to support *E. coccifera* and, as erosion is barely balanced by weathering, cannot become deeper. In other places, however, where the soil can accumulate from the weathering of higher elevations, such as the foot of the Mt. Arthur ridge, the *E. coccifera* is invading the grassland slowly.

CONCLUSIONS

The Eucalypt Forest Types

These range from dwarfed and fairly open *E. coccifera* forest on the summit to the dense *E. regnans* of the lower slopes. The species show definite vertical sequence. *E. coccifera* exists as a pure consociation down to about 3600 ft. below which the *E. urnigera* appears in increasing amounts to 2500 ft., where it is succeeded by *E. gigantea* and *E. obliqua-regnans*, which is replaced by the open forests and *E. globulus* communities of the lower slopes.

Four main types have been recognized:

(1) *E. coccifera* Consociation

This natural consociation is believed to be widespread in Tasmania, and represents the upper limit of the invasion of the Eucalyptus formation into the Austral-Montane formation. In comparing it with *E. nipophila*⁽¹⁾ consociation 1000 ft. higher at Kosciusko, it is apparent that the shrub layer on Mt. Wellington is of greater richness and importance, and from a Tasmanian viewpoint the facies at Kosciusko is relatively 'warmer' and mesomorphic. The shrubs in common are *Drinys lanceolata*, *Helichrysum baccharides* (*Ozothamnus Hookeri*) *Oxylobium ellipticum*, *Podocarpus alpina*, *Richea Gunnii* and *Lissanthe montana*, and of these only *Helichrysum baccharoides*, *Podocarpus alpina*, *Lissanthe montana* and *Richea Gunnii* are generally confined to the *E. coccifera* consociation; the others reach their greatest importance at lower levels. Many of the commonest shrubs in the Kosciusko consociation, e.g., *Veronica derwentia*, *Helichrysum rosmarinifolium*, *Olearia myrsinoides*, *Prostanthera cuneata*, *Cassinia aculeata* occur in Tasmania at very much lower levels only, and the genera of most of the others are represented by low altitude species. The herb species show a similar distribution.

As it is probable that the climate of Kosciusko is much colder than at Mt. Wellington, the 'warmness' of the shrub facies at the former presents an interesting problem. It may be noted that it is the xeromorphic Kosciusko species which are represented in the *E. coccifera* consociation, while the mesomorphic *Veronica derwentia*, *Helichrysum rosmarinifolium*, *Cassinia aculeata* are restricted to lower levels which suggests that the difference may be due to the water factor. Unless we assume the existence of strains of different cold resistance in the two places, their absence in *E. coccifera* cannot be due to the temperature but to water availability. The extremely rocky nature of the terrain, the scanty or shallow soil with poor water-retaining capacity, droughts and high winds prevents the establishment of the water-loving species.

It seems not impossible that the endemism of many of the montane species of Epacridaceae and Proteaceae, etc., in Tasmania may be due in part to the advantage their xeromorphic habit gives them over the more mesomorphic forms which dominate the shrub layer at Kosciusko and which can exist in Tasmania only at lower levels.

The *E. Gunnii* consociation described for Kosciusko by McLuckie and Petrie (1927) does not occur on Mt. Wellington. The species referred to there is not

(¹) = *E. pauciflora* = *E. coriacea* of McLuckie and Petrie (1927).

the *E. Gunnii* of Tasmania, but is probably *E. glaucescens* (Blakely, 1934). In Tasmania *E. Gunnii* Hook. forms societies at 2500 ft. to 3500 ft. on the Central Plateau, where it prefers marshy conditions and bears little ecological resemblance to the Kosciuszko association.

The *E. pauciflora* association of Barrington Tops (Fraser & Vickery, 1937-9) is also not present on the area studied. This species occurs in Tasmania in the 'Midlands' and Central Plateau as extensive open forest. The two associations may be ecologically related, but the local one is yet to be studied. The definite identity of the species in the two places is yet to be confirmed (Brett, 1938).

(2) *The E. coccifera-urnigera* Association

This association is formed by the entry of *E. urnigera* into the *E. coccifera* forest at below 3600 ft. It competes successfully with the slower-growing species under favourable conditions, and on Mt. Wellington has invaded and displaced it over considerable areas. It is, however, less cold, wind and drought resistant, and upward extension is limited by these factors. Extension to lower levels is limited by the competition of the vigorous *E. gigantea* and *E. obliqua-regnans*.

On Mt. Wellington *E. Johnstoni* occurs in the *E. urnigera* association. This species, however, does not assume the importance that its close relative *E. subcrenulata* does on other mountains. A widely-occurring *E. coccifera-subcrenulata-urnigera* association may eventually be defined of which the Mt. Wellington association with *E. Johnstoni*, vice *E. subcrenulata*, will form a part.

The relation of *E. urnigera* to the dolerite talus slope has been described above (p. 102). Little soil exists in this region, and the water quickly percolates through; consequently the shrub layer is still predominantly xeromorphic. The less heliophilous species from the *E. coccifera* consociation above and the more drought-resistant species from the *E. obliqua-regnans* below mingle.

It seems probable that *E. urnigera*, which has perhaps been evolved in Tasmania, has proved specially suited to resist competition on this specialized habitat to which it is still largely confined. Following fires, it competes successfully with *E. coccifera*, but a series of very severe winters will probably reverse this tendency. At lower levels it cannot compete successfully with *E. regnans* and *E. gigantea*, though it persists in these associations as a minor element down to 2000 ft. It is not found off the talus soils, though it can be cultivated on any moist well drained soil type. In swampy places in its own association or even in the upper parts of the *E. obliqua-regnans* association, *E. urnigera* exists as a shrub, often not losing its juvenile foliage. It is a species of great ecological interest, confined to Tasmania, but with affinities there only with *E. divaricata* (see Brett, 1938).

(3) *E. obliqua-regnans* Association

This rather loose association comprises the chief commercial forests in S.E. Tasmania. The composition varies markedly with changes in local climate, *E. obliqua* predominating in the drier parts and *E. regnans* in the more sheltered. Its upper limits are defined by temperature and by soil type and the lower by rainfall. It is thus characteristic of mudstone soils with a rainfall of over 35 in. per annum.

At its upper limits in the drier parts the *E. obliqua* is replaced by *E. gigantea*. On the lower limits, where the rainfall is below 40 in., the *E. obliqua* element of the more exposed parts is replaced by the open forest association and the *E. regnans* element of the more sheltered regions by the *E. globulus-obliqua* communities.

A general comparison of this association with portion of the Eucalypt forest of Barrington Tops (see Fraser & Vickery, 1937-9) is possible. There the crests

and upper slopes of the ridges 2800-3500 ft. are occupied by *E. obliqua* forest. This gives place to *E. viminalis*, which is in turn replaced by *E. fastigata* at 4200 ft. (*E. fastigata* is closely related to *E. regnans* (see Blakely, 1934)). The higher rainfall at Barrington is probably offset by the greater seasonal variation and higher average temperature, which would also tend to equalize differences in altitude. A comparison of the shrub and fern layers shows many species in common, though the richness and importance of the tall shrub layer in the Tasmanian association is in marked contrast.

The two areas have another feature in common, the presence of subantarctic rain forest in the 'gullies'. On Mt. Wellington these gullies are of course very small in comparison with the wide valleys, whose sides are occupied by this formation in the other case.

The ecological position of *E. viminalis* in these areas and at Kosciusko is worthy of special attention. At the latter place it forms an association with *E. Gunnii* (*E. glaucescens*), while at Barrington it forms an association with *E. obliqua*. On Mt. Wellington it occurs occasionally in the driest portions of the *E. obliqua-regnans* association and in the more sheltered portions of the open forest, but cannot compete with *E. regnans* or *E. globulus* in the regions of higher moisture. Thus it occupies a very minor ecological position in south-east Tasmania, though it forms an important element in other parts. It is interesting to note that at Barrington it cannot compete with *E. fastigata*, which is closely related to *E. regnans*.

Its ecological position has brought *E. viminalis* frequently in contact with *E. globulus*, *E. salicifolia*, etc., with which it has hybridized freely (Brett, 1938). Another ecological juxtaposition which may have produced similar results in the distant past is shown by the case of *E. Johnstoni*, which is suspected by Brett (1938) of having arisen as the result of the stabilization of a hybrid between *E. subcrenulata* and *E. globulus*. Mt. Wellington is one of the few places in Tasmania where the montane dolerite talus, characterized by *E. subcrenulata*, has made contact with the upper edge of the *E. globulus* community. This would at least bring the two species in contact and go some distance to explaining the absence of *E. Johnstoni* from similar habitats on the central mountains. On Mt. Wellington, *E. Johnstoni* is scattered through the *E. urnigera* range, with which it has probably hybridized (Brett, 1938).

(4) Open Forest Association of the Lower Slopes

The study of ecology of the Eucalypts of this region has not been attempted; the problem is essentially one for the specially trained Eucalyptologist. Primarily distribution is a matter of varying degrees of xeromorphism, the order of increasing drought resistance being, *E. globulus*, *E. obliqua*, *E. viminalis*, *E. linearis*, *E. salicifolia*, *E. tasmanica*. However, the existence of complex hybrid swarms connecting two or more species, together with considerable denudation, would make the task of greater than its ecological importance warrants. The shrub and herb species are typical of the open forests of south-east Australia.

The Austral-Montane Formation

This may be divided into three main parts:

(a) Shrubberies

These consist of masses of low shrubs, occupying the small patches of soil amongst the large masses of boulders. The important elements are all 'Australian' (Maiden, 1914). Herbs belonging to the sub-antarctic element occur, but they play little part in the maintenance of the community. The important feature of the

vegetation is its extreme xeromorphism. This is a response to the edaphic and climatic conditions, which preclude the establishment of any mesophytic perennials. This has meant the sifting out of many of the types characteristic of the more complete development of the formation in other parts. The shrubberies of alpine conifers, *Phaerosphaera Diselma*, *Microcachrys* and of *Nothofagus Gunnii* and *N. Cunninghami*; trees of *Arthrotaxis* spp. are absent. There is also no solid mat of herb mosaics and only one 'bolster' plant is present.

It thus represents a marked contrast to Mt. Field, only 30 miles to the west, where at a slightly higher altitude with heavier rainfall and deeper and more lasting snow, these communities are fully developed.

(b) Swamps

The swamps bear some resemblance to those of Barrington Tops and Kosciusko, and many species are common to all three, e.g., *Hypolaena laterifolia*, *Restio australis*, *Euphrasia collina*, *Epacris serpillifolia*, *Orreomyrhris andicola*. Also the waterlogging of the soil affects the advance of the Eucalypt formation similarly. However, the local community presents several important differences. *Sphagnum* does not appear to play as important a part in the succession. This occurs free-floating in many of the pools and as occasional mounds in the more mature part, but development is not extensive. The inclusion of *Astelia* as a very important element makes the character of the vegetation entirely different; its thick stiff leaves and matted habit provides a firm basis, which the other elements, *Gleichenia dicarpa*, *Restio australis*, *Hypolaena laterifolia*, bind together in a solid mass. This is often firm and dry enough to permit shrubs such as *Richea* spp., *Orites acicularis*, etc., to maintain a semiepiphytic existence. *Baeckia Gunniana* plays a very much more, and *Epacris* spp. a very much less, important part in the succession on Mt. Wellington than in the other places. The position of *Abrotanella Fosterioides* is dealt with.

The problem of deciding what climatic sifting has maintained *Astelia alpina* in its important position in the Austral-Montane formation in Tasmania and prevented its appearance at Kosciusko and Barrington is an interesting one.

(c) Grassland

The *Poa caespitosa* grassland appears to have two origins, the first as a phase in the succession from the swamp to the *E. coccifera* consociation as a result of the slow draining of the swamp, and secondly as a probable subclimax in the higher parts on shallow, but well-drained, soils where accumulation from weathering is balanced by denudation. Shrubs are well represented and a certain number of other herbs and annuals, but the latter are more frequent in the grassland swamp ecotone.

Comparison with Cradle Mt. (Sutton, 1929)

The higher average rainfall of Cradle Mt. has permitted the development of a more complete Austral-Montane formation, which includes all those species which are excluded by the drier conditions from Mt. Wellington and having in greater quantities those plants which are rare there. In addition, Cradle Mt. supports a microthermal rain forest formation of the West Coast type and a Button Grass association. The grassland associations are practically identical, while the *E. coccifera* consociation is enriched by the greater development of *Nothofagus Cunninghami* and the presence of *N. Gunnii* and *Phyllocladus rhomboidialis* and other species all indicative of better water conditions.

The Hartz Mts., 30 miles S.W. of Hobart, provide another comparison of the influence of climate on floral composition in Tasmania. These mountains receive rainfall intermediate between that of Cradle Mt. and Mt. Wellington, while there

is probably little difference in the winter temperatures of the two places. In response to those conditions, the vegetation has developed an intermediate composition. *Arthrotaxis* does not develop in the microthermal rain forest, but is restricted to the edge of the alpine lakes; the shrubberies of alpine conifers and the level plant mosaics are present but poorly developed; on the other hand these other species such as *Milligania* sp. and *Aciphylla procumbens*, etc., which are absent from Mt. Wellington, do occur. The microthermal rain forest is quite extensive in the upper parts of the valleys draining the area, but not as rich as this formation at Cradle Mt.

Ecological Relationships of the Formations

All available evidence goes to show that it is the amount of available water which holds the balance between the Eucalyptus formation and the microthermal rain forest and Austral-Montane formations. In the first case the climate at 2000-3000 ft. is too dry to permit the advance of the microthermal rain forest beyond the sheltered gullies. The balance is not very much in favour of the Eucalypt, for the presence of occasional *Nothofagus* trees in the *E. regnans* forest and the difficulty of replacement of the Eucalyptus trees in the shady tall shrub layer, indicate that it would not require a great increase in rainfall or rainfall reliability to permit the advance of the *Nothofagus* community, with a lower light requirement into the other formation.

In the second case, towards the summit there is no question of the light factor playing any part, and the advance of Eucalypt formation into the Austral-Montane is restrained by poor water-supply, due to edaphic conditions or to exposure to wind in the case of the shrubberies and grassland, or by excessive water in the case of the swamps. It is very unlikely that low temperatures play any significant part in Eucalypt distribution on the summit.

GENERAL SUMMARY

The area studied includes the eastern end of the Mt. Wellington range between 800 and 4166 ft. (with a brief description of the open forest outside this area), lying about 5 miles west of Hobart (lat. 42° 54', long. 147° 17'). The mass consists of a dolerite sill, approx. 1600 ft. thick, overlying sandstones and mudstones.

The rainfall varies with altitude from 24" to approx. 60" per annum.

At higher altitudes the soils are high moor and skeletal types, and below 2500 ft. podsol types. The upper portion of the mountain is very rocky and the soil thin or scanty.

Three plant formations (two in reduced form) are represented:

1. Eucalypt forest.
2. Microthermal rain forest.
3. Austral-Montane.

The Eucalypt forest ranges from open forests of the drier low altitudes through dense forests of large trees with an important tall shrub layer to stunted, fairly open, montane-subalpine forest on the summit plateau.

The microthermal rain forest exists as a 'gully flora' in the upper parts of the large tree forests.

The Austral-Montane formation occupies the small area on the summit plateau not occupied by dwarf Eucalypt forest.

The Eucalypt forest has been divided into four types:

- (a) *E. coccifera* consociation with low shrubs (3500-4000 ft.)
- (b) *E. coccifera-urnigera* association with tall and low shrubs (2400-3500 ft.).

- (c) *E. obliqua-regnans* association with dense tall shrub layer (app. 1000-2500 ft.) and with 'gully' and sandstone communities.
- (d) Open forest associations occupying the tops and dryer sides with *E. globulus* communities on the moister sides of the ridges below 1000 ft.

Associations (a), (b); and (c) have been described briefly and compared and contrasted with Eucalyptus associations at Kosciusko and Barrington Tops. A very brief description of association (d) is also given. The 'gully flora' and sandstone communities within the Eucalyptus formation have been described. The relation of this formation with the reduced microthermal rain forest and Austral-Montane formations has been discussed briefly.

The relations of the reduced montane flora of Mt. Wellington to that of other mountains in Tasmania and the sifting effect of climate (mainly rainfall) on its composition are described.

A census of the plant species in the area is presented.

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APPENDIX

The following table has been compiled as the result of observation and collecting over a period of years.

Column 1. Austral-Montane formation of the summit plateau,

- „ 2. *E. coccifera* consociation,
 „ 3. *E. coccifera-urnigera* association,
 „ 4. *E. obliqua-regnans* association,
 „ 5. Sandstone communities,
 „ 6. Gully communities,
 „ 7. Open forest association.

Abbreviations, vc = very common, c = common, lc = locally common, f = frequent, o = occasional, r = rare, vr = very rare.

In order to increase the usefulness of the census, plants recorded by reliable collectors but not observed by the author have been included and marked with an asterisk (*). For sections 1-6 the list may be regarded as fairly complete, but in the case of the open forest association, 7, there may be many omissions, not only because the association lay outside the area studied in more detail but also because it has been greatly altered by the proximity of Hobart and many aliens occur.

The terminology of Ewart's Flora of Victoria and Black's Flora of South Australia has been generally adopted except for the Filices, where that of Melvaine (1936) was used.

	1	2	3	4	5	6	7
Gramineae							
* <i>Agrostis alba</i> L.							
<i>parviflora</i> R.Br.	r	vr	vr	o	—	—	—
<i>Anthoxanthum odoratum</i> L. up to 3000'							
* <i>Arrhenantherum elatius</i> L.							
* <i>Calamagrostis minor</i> Benth.							
<i>Cynosurus cristatus</i> L. up to 2500'							
<i>Dactylis glomerata</i> L. up to 2500'							
* <i>Danthonia pallidax</i> R.Br.	—	—	—	c	—	—	c
<i>pauciflora</i> R.Br.	r	r	r	o	—	—	—
<i>racemosa</i> R.Br.	—	—	r	c	—	—	c
<i>semiannularis</i> R.Br.	—	—	—	c	—	—	vc
* <i>Deyeuxia accidens</i> J. Vickery							
* <i>Benthamiana</i> J. Vickery							
* <i>densa</i> Benth.							
* <i>monticola</i> (R & S). J. Vickery							
* <i>quadrisecta</i> (Lab). Benth.							
* <i>Rodwayi</i> J. Vickery							
* <i>scaberula</i> J. Vickery							
<i>Dichelachne crinata</i> Hook.	—	—	—	o	—	—	—
<i>Hierochloe Fraseri</i> Hook.	c	o	r	—	—	—	—
<i>redolens</i> R.Br.	o	o	o	c	—	—	—
<i>Holcus lanatus</i> L.	—	—	f	vc	o	—	c
* <i>Melia californica</i> Nell.							
<i>Microlaena stipitoides</i> R.Br.	—	—	o	—	—	—	c
<i>tasmanica</i> R.Br.							
var. <i>subalpina</i>	vr	—	—	—	—	—	—
* <i>Pentapogon quadrifidus</i> Baill.							
<i>Stipa aphylla</i> Rodway	—	—	—	—	—	—	o
<i>setacea</i> R.Br.	—	—	—	c	—	—	—
<i>Themeda triandra</i> Forsk.	—	—	—	c	—	—	vc
Cyperaceae							
<i>Carpha alpina</i> R.Br.	vc	o	o	—	—	—	—
<i>Carex breviculmis</i> R.Br.	—	—	—	—	—	—	r
<i>gaudichaudiana</i> Kunth.	—	—	—	o	—	—	r
<i>longifolia</i> R.Br.	—	—	—	o	—	f	o
* <i>tasmanica</i>	—	—	—	—	—	—	r

	1	2	3	4	5	6	7
<i>Gahnia graminifolia</i> Rodway	—	—	—	o	o	—	o
<i>psittacorum</i> Lab.	—	—	f	c	c	c	f
<i>radula</i> Benth.	—	—	—	o	o	—	—
<i>Lepidosperma filiforme</i> Lab.	—	—	—	vr	—	—	r
<i>elatus</i> Lab.	—	—	—	—	—	—	—
var. <i>Oldfieldii</i>	—	—	—	o	—	—	o
<i>laterale</i> R.Br.	—	—	—	r	—	—	o
<i>lineare</i> R.Br.	—	—	—	—	—	—	—
var. <i>inops</i> .	—	—	—	r	—	—	o
<i>squamata</i> Lab.	—	—	—	o	o	—	f
<i>Oreobolus pumilio</i> R.Br.	f	—	—	—	—	—	—
* <i>Scirpus cernuus</i> Vahl.	—	—	—	o	—	—	—
<i>crassiculatus</i> Hook.	f	—	—	—	—	—	—
<i>fluitans</i> L.	—	—	—	r	—	—	—
<i>imundatus</i> Spreng.	o	—	—	f	—	—	—
* <i>setaceus</i> L.	—	—	—	r	—	—	—
* <i>Schoenus apogon</i> R. & S.	—	—	—	—	—	—	r
* <i>axillaris</i> Hook.	—	—	—	r	—	—	—
<i>tenuissimus</i> Benth.	—	—	—	r	o	—	—
<i>Uncinia compacta</i> R.Br.	f	r	r	—	—	—	—
<i>riparia</i> R.Br.	—	—	—	—	—	r	—
<i>tenella</i> R.Br.	r	—	—	o	r	—	—
Restionaceae							
<i>Hypolaena laterifolia</i> Benth.	vc	c	f	f	f	—	—
<i>Restio australis</i> R.Br.	lc	—	—	—	lc	—	—
* <i>complanatus</i> R.Br.	—	—	—	—	—	—	—
* <i>oligocephalus</i> F.v.M.	—	—	—	—	—	—	—
Centrolepidaceae							
<i>Centrolepsis aristata</i> R. & S.	—	—	—	—	o	—	o
<i>fascicularis</i> Lab.	—	—	—	—	r	—	r
<i>strigosa</i> R. & S.	—	—	—	—	o	—	r
Juncaceae							
<i>Juncus bufonius</i> L.	—	—	—	o	o	—	r
<i>communis</i> Mey.	—	—	—	lc	—	—	lc
<i>pallidus</i> R.Br.	—	—	—	o	—	—	o
<i>planifolius</i> R.Br.	—	—	—	f	—	—	f
<i>pauciflorus</i> R.Br.	—	—	—	o	—	—	o
<i>prismatocarpus</i> R.Br.	—	—	—	r	—	—	o
<i>Luzula campestris</i> D.C.	o	—	r	f	—	—	r
<i>Oldfieldii</i> Hook.	c	o	r	—	—	—	—
Liliaceae							
<i>Anguillaria dioica</i> R.Br.	—	—	—	o	—	—	c
<i>Arthropodium paniculatum</i> R.Br.	—	—	—	—	—	—	o
<i>Astelia alpina</i> R.Br.	vc	lc	o	—	—	—	—
<i>Bulbine bulbosa</i> Haw.	—	—	—	o	—	—	o
<i>Dianella revoluta</i> R.Br.	—	—	—	o	o	—	f
<i>tasmanica</i> Hook.f.	—	—	vr	c	c	—	—
<i>Drymophora cyanocarpa</i> R.Br.	—	—	f	c	—	—	—
<i>Stypandracea sp.</i> R.Br.	—	—	—	—	—	—	o
<i>Thysanotus Patersoni</i> R.Br.	—	—	—	—	—	—	o
<i>Xerotes longifolia</i> R.Br. (Lomandra)	—	—	—	o	—	—	vc
Amaryllidaceae							
<i>Hypoxis hygrometrica</i> Lab.	—	—	—	—	—	—	o
Iridaceae							
<i>Diplarrhena moraea</i> Lab.	—	—	—	c	—	—	vc
Orchidaceae							

N.B.—All the members of this family in the area are geophytes. It is difficult to form a reliable estimate of the frequency, and many species recorded as occasional or rare may become locally common.

<i>Acianthus caudatus</i> R.Br.	r	—	—	f	—	—	o
* <i>exsertus</i> R.Br.	—	—	—	—	—	—	o
* <i>reniformis</i> R.Br.	—	—	—	—	—	—	r
<i>viridis</i> Hook.	—	—	—	f	—	—	o
<i>Caladenia angustata</i> Lindl.	—	r	r	o	r	—	r
<i>carnea</i> R.Br.	—	—	—	—	—	—	o
<i>dilatata</i> R.Br.	—	—	—	o	—	—	f
* <i>filamentosa</i> R.Br.	—	—	—	—	—	—	r
* <i>Patersoni</i> R.Br.	—	—	—	—	—	—	r
* <i>suaveolens</i> Reichb.	—	—	—	—	—	—	r
* <i>testacea</i> R.Br.	—	—	—	—	—	—	r
<i>Caleana major</i> R.Br.	—	—	—	—	—	—	o
<i>minor</i> R.Br.	—	—	—	—	—	—	o
* <i>Calochilus campestris</i> R.Br.	—	—	—	—	—	—	o
<i>Chilogottis Gunnii</i> Lindl.	—	—	—	vr	—	—	—
<i>Cryptostylis reniformis</i> Lindl.	—	—	—	—	—	—	r
<i>Dipodium punctatum</i> R.Br.	—	—	—	vr	—	vr	vr
<i>Diuris maculata</i> Sm.	—	—	—	—	—	—	f
* <i>pedunculata</i> R.Br.	—	—	—	—	—	—	o
* <i>palustris</i> Lindl.	—	—	—	—	—	—	r
<i>sulphurea</i> R.Br.	—	—	—	—	—	—	f
<i>Eriochilus cucullatus</i> (Lab.) Reichb.	—	—	—	—	—	—	r
<i>Gastrodia sesamoides</i> R.Br.	—	—	—	r	—	r	vr
<i>Glossodia major</i> R.Br.	—	—	—	—	—	—	f
<i>Microtis porrifolia</i> R.Br.	—	—	—	—	—	—	o
* <i>Pterostylis barbata</i> Lindl.	—	—	—	—	—	—	r
* <i>cucullata</i> R.Br.	vr	vr	vr	r	r	—	o
<i>longifolia</i> R.Br.	—	—	—	r	f	—	f
<i>nutans</i> R.Br.	—	—	—	o	—	—	o
* <i>obtusata</i> R.Br.	—	—	—	r	r	—	r
* <i>parviflora</i> R.Br.	—	—	—	—	—	—	r
* <i>rufa</i> R.Br.	—	—	—	—	—	—	r
* <i>squamata</i> Lindl.	—	—	—	—	—	—	r
<i>Prasophyllum australe</i> R.Br.	—	—	—	r	—	—	o
* <i>brachystachyum</i> Lindl.	—	—	—	—	—	—	r
* <i>dissectans</i> Hook.f.	—	—	—	—	—	—	r
<i>elatum</i> R.Br.	—	—	—	—	—	—	r
* <i>brevilabre</i> Hook.f.	—	—	—	r	—	—	o
<i>fusum</i> R.Br.	o	—	—	o	r	—	o
<i>nigricans</i> R.Br.	—	—	—	r	—	—	o
* <i>patens</i> R.Br.	r	—	—	o	—	—	o
* <i>rufum</i> R.Br.	—	—	—	—	—	—	r
<i>Spiranthes australis</i> Lindl.	—	—	—	—	—	—	vr
<i>Thelymitra carnea</i> R.Br.	—	—	—	—	—	—	o
<i>ixiodes</i> Sw.	—	—	—	—	—	—	o
<i>venosa</i> R.Br.	—	—	—	r	—	—	o
Burmanniaceae							
* <i>Thismia Rodwayi</i> F.v.M.	—	—	—	—	—	vr	—

DICOTYLEDONS

Casurinaceae							
<i>Casurina stricta</i> Ait.	—	—	—	—	—	—	lc
Fagaceae							
<i>Nothofagus Cunninghami</i> Hook. f. Oers.	—	—	—	lc	—	c	—
Proteaceae							
<i>Banksia marginata</i> Cav.	—	—	o	c	o	—	c
<i>Bellenden montana</i> R.Br.	vc	c	o	—	—	—	—
<i>Grevillea australis</i> R.Br.	—	vr	vr	—	—	—	—
<i>Hakea serecea</i> Sch.	—	—	c	o	—	—	—
var. <i>lissosperma</i>	—	—	—	o	o	—	—
<i>epiglottis</i> Lab.	—	—	vr	vr	—	—	—
<i>Lomatia polymorpha</i> R.Br.	vr	vr	vr	—	—	—	—
<i>tinctora</i> R.Br.	—	—	o	vc	c	—	vc

	1	2	3	4	5	6	7
<i>Orites acicularis</i> R.Br.	vc	c	—	—	—	—	—
<i>diversifolia</i> R.Br.	—	r	f	o	—	—	—
<i>revoluta</i> R.Br.	c	c	r	—	—	—	—
<i>Persoonia juniperina</i> R.Br.	—	—	—	r	—	—	o
<i>Telopea truncata</i> R.Br.	—	o	c	r	—	—	—
Santalaceae							
<i>Ezocarpus cupressiformis</i> Lab.	—	—	—	f	—	—	f
<i>humifusa</i> R.Br.	c	o	—	—	—	—	—
<i>stricta</i> R.Br.	—	—	—	f	—	—	f
<i>Leptomeria Billardieri</i> R.Br.	—	—	—	r	—	—	o
Malvaceae							
<i>Plagianthus sidiodes</i> H.	—	—	—	o	—	o	—
Portulacaceae							
* <i>Claytonia australasica</i> H.	—	—	—	—	—	—	—
Caryophyllaceae							
* <i>Moenchia flaccida</i> H.	vr	—	—	—	—	—	—
<i>Stellaria flaccida</i> H.	—	—	—	o	—	—	—
Ranunculaceae							
<i>Clematis aristata</i> R.Br.	—	—	—	f	—	f	—
<i>gentianoides</i> D.C.	—	—	—	—	—	—	o
<i>Ranunculus hirtus</i> Banks & Sol.	—	—	f	f	—	—	—
<i>lappaceus</i> Sm.	—	—	—	f	—	o	o
*I <i>parviflorus</i> Ehr.	—	—	—	—	—	—	—
*I <i>philonotis</i> Ehr.	—	—	—	—	—	—	—
*I var. <i>pimperenellifolius</i>	—	—	—	—	—	—	—
* <i>rivularis</i>	—	—	—	—	—	—	—
* var. <i>inundatus</i>	—	—	—	—	—	—	—
Winteraceae							
<i>Drimys lanceolata</i> (Poir) Baill.	f	c	c	f	o	o	—
Monimiaceae							
<i>Atherosperma moschatum</i> Lab.	—	—	vr	r	—	vc	—
Cruciferae							
I <i>Brassica sinapistrum</i> Boiss	—	—	—	o	—	—	—
<i>Cardamine hirsuta</i> L.	—	—	—	o	—	—	—
var. <i>tenuifolia</i> H.	f	f	f	o	—	—	o
<i>stylosa</i> D.C.	—	—	—	r	—	—	—
Lauraceae							
<i>Cassytha pubescens</i> R.Br.	—	—	—	o	—	—	f
Pittosporaceae							
<i>Billardiera longiflora</i> Lab.	—	—	—	f	—	—	o
* var. <i>alpina</i>	—	—	r	—	—	—	—
<i>Bursaria spinosa</i> Cav.	—	—	—	—	—	—	vc
<i>Marianthus procumbens</i> B.	—	—	r	—	—	—	o
<i>Pittosporum bicolor</i> H.	—	r	f	f	—	f	—
Saxifragaceae							
<i>Anopterus glandulosus</i> Lab.	—	—	—	o	—	o	—
<i>Bauera rubiodes</i> Andr.	f	f	c	r	o	—	—
<i>Tetracarpaea tasmanica</i> H.	o	r	r	—	—	—	—
Rosaceae							
<i>Acaena ovina</i> Cunn.	—	—	—	—	—	—	o
<i>sanguisorba</i> Vahl.	o	o	c	vc	c	—	c
var. <i>montana</i>	r	—	—	—	—	—	—

	1	2	3	4	5	6	7
I <i>Rubus fruticosus</i> L.	—	—	—	o	—	o	c
<i>Gunnianus</i> H.	o	o	o	—	—	—	—
<i>parvifolius</i> L.	—	—	—	f	—	—	o
Droseraceae							
<i>Drosera arcturi</i> H.	f	—	—	—	—	—	—
<i>auriculata</i> Back.	—	—	—	o	f	—	c
<i>binata</i> Lab.	—	—	—	o	f	—	—
<i>pygmaea</i> D.C.	—	—	—	o	o	—	—
Leguminosae							
<i>Acacia dealbata</i> Link.	—	—	—	vc	—	f	vc
<i>decurrens</i> Willd.	—	—	—	o	—	—	vc
<i>diffusa</i> Lindl.	—	—	—	o	—	—	c
<i>discolor</i> Willd.	—	—	—	f	—	—	f
<i>melanoxydon</i> R.Br.	—	—	—	c	—	c	o
<i>myrtifolia</i> Willd.	—	—	—	—	—	—	c
<i>riceana</i> Hens.	—	—	—	o	o	o	f
<i>verniciiflua</i> A. Cunn.	—	—	—	vc	c	o	f
<i>verticillata</i> Willd.	—	—	—	o	o	—	lc
<i>vomeriformis</i> A. Cunn.	—	—	—	—	—	—	f
<i>stricta</i> Willd.	—	—	—	—	—	—	c
<i>Aotus villosa</i> Sm.	—	—	—	o	o	—	c
<i>Bossiaea prostrata</i> R.Br.	—	—	—	—	—	—	f
<i>Daviesia latifolia</i> R.Br.	—	—	—	o	o	o	lc
<i>ulicina</i> Sm.	—	—	—	o	—	—	lc
<i>Dillwynia cinerascens</i> R.Br.	—	—	—	o	—	—	f
<i>floribunda</i> Sm.	—	—	—	o	—	—	c
<i>Goodia lotifolia</i> Salisb.	—	—	—	o	—	—	r
<i>Hovea heterophylla</i> Cunn.	—	—	—	—	—	—	o
<i>Indigophora australis</i> Willd.	—	—	—	o	—	—	o
<i>Kennedyia prostrata</i> R.Br.	—	—	—	—	—	—	c
<i>Pultenea daphnoides</i> Wend.	—	—	—	c	—	—	c
* <i>dentata</i> Lab.	—	—	—	—	—	—	r
<i>Gunnii</i> Benth.	—	—	—	o	—	—	f
var. <i>baecklodes</i>	—	—	—	o	—	—	o
<i>juniperina</i> Lab.	—	—	—	vc	—	—	vc
<i>stricta</i> Sims.	—	—	—	o	—	—	f
<i>tenuifolia</i> R.Br.	—	—	—	—	—	—	vr
<i>Oxylobium ellipticum</i> R.Br.	—	o	o	vc	vc	o	c
<i>Sphaerolobium vimineum</i> Sm.	—	—	—	—	—	—	r
I <i>Trifolium agrarium</i> L.	—	—	—	—	—	—	—
I <i>glomeratum</i> L.	—	—	—	—	—	—	—
I <i>pratense</i> L.	—	—	—	—	—	—	—
I <i>repens</i> L.	—	—	—	—	—	—	—
I <i>Ulex europaeus</i> L.	—	—	—	—	—	—	—
Geraniaceae							
<i>Geranium dissectum</i> L.	f	f	c	c	—	—	f
<i>sessiflorum</i> Cav.	o	o	o	—	—	—	o
<i>Perlargonium australe</i> Willd.	—	—	—	r	—	—	r
Oxalidaceae							
<i>Oxalis magellanica</i> Forst.	r	o	o	o	—	—	—
Rutaceae							
<i>Boronia pilosa</i> Lab.	—	—	—	vr	—	—	o
<i>pinnata</i> Sm.	—	—	—	r	—	—	f
* <i>polygalifolia</i> Lab.	—	—	—	—	—	—	vr
<i>Correa rubra</i> Sm.	—	o	c	c	o	r	f
<i>Lawrenciana</i> Hook.	—	o	c	f	o	r	f
<i>Eriostemon obovalis</i> Cunn.	—	—	—	—	—	—	f
<i>Phebalium squameus</i> Lab.	—	—	—	vc	vc	c	vr
<i>Zieria Smithii</i> Andr.	—	—	—	c	—	f	—

	1	2	3	4	5	6	7
Stackhousiaceae							
<i>Stackhousia linearifolia</i> A. Cunn.	—	r	r	o	—	—	f
Rhamnaceae							
<i>Pomaderris apetala</i> Lab.	—	—	—	vc	o	vc	r
* <i>elacophylla</i> F.v.M.	—	—	—	—	—	—	c
* <i>elliptica</i> Lab.	—	—	—	—	—	—	c
* <i>racemosa</i> Hook.	—	—	—	—	—	—	vr
<i>Spryidium ulicinum</i> Benth.	—	—	—	—	—	—	vr
Sapindaceae							
<i>Dodonaea viscosa</i> L.	—	—	—	f	—	—	l
Linaceae							
I <i>Linum catharticum</i> L.	—	—	—	—	—	—	o
I <i>gallicum</i> L.	—	—	—	—	—	—	o
Urticaceae							
* <i>Australina Meulleri</i> Wedd.	—	—	—	r	—	r	—
<i>pusilla</i> Gaud.	—	—	—	r	—	r	—
<i>Urtica incisa</i> Poir.	—	—	—	l	—	l	—
Polygalaceae							
<i>Bredemeyera retusum</i> (Steetz). Chod.	—	—	—	o	—	—	o
<i>volubile</i> (Steetz). Chod.	—	—	—	f	—	—	c
Euphorbiaceae							
<i>Amperea spartioides</i> Bron.	—	—	—	c	c	—	v
<i>Beyeria viscosa</i> Miq.	—	—	—	c	—	c	lc
* <i>Poranthera microphylla</i> Bron.	o	—	—	—	—	—	—
Solanaceae							
<i>Solanum aviculare</i> Forst.	—	—	—	r	—	vr	—
Tremandraceae							
<i>Tetratheca glandulosa</i> Lab.	—	—	—	f	—	—	vc
<i>pilosa</i> , Lab.	—	—	—	f	—	—	vc
Elaeocarpaceae							
<i>Aristotelia peduncularis</i> Hook.	—	—	o	f	—	—	f
Dilleniaceae							
<i>Hibbertia fasciculata</i> R.Br.	—	—	—	—	o	—	f
<i>hirsuta</i> Benth.	—	—	—	—	—	—	o
<i>procumbens</i> D.C.	—	—	—	—	—	—	o
<i>stricta</i> R.Br.	—	—	—	r	o	—	f
Guttiferae							
I* <i>Hypericum androsaemum</i> L.	—	—	—	—	—	—	r
<i>graminium</i> Forst.	—	—	—	r	o	—	o
I* <i>japonicum</i> Thunb.	—	—	—	—	—	—	r
Violaceae							
<i>Viola hederacea</i> Lab.	—	e	r	o	r	o	f
Thymeliaceae							
<i>Pimelia cineria</i> R.Br.	—	—	—	r	—	—	o
<i>drupacea</i> Lab.	—	—	—	c	—	f	—
<i>flava</i> R.Br.	—	—	—	r	—	—	o
<i>nivea</i> Lab.	—	—	r	lc	o	—	c
<i>serecea</i> R.Br.	c	o	r	—	—	—	—
* <i>involuta</i> Banks & Sol.	—	—	—	—	—	—	o
* <i>humilis</i> R.Br.	—	—	—	—	—	—	r
Myrtaceae							
<i>Baeckia Gunniana</i> Schau.	vc	f	—	—	—	—	—
* <i>ramosissima</i> A. Cunn.	—	—	—	—	—	—	vr

	1	2	3	4	5	6	7
<i>Callistemon salignus</i> D.C.	—	—	—	o	o	—	—
<i>Eucalyptus coccifera</i> Hook.f.	—	d	sd	—	—	—	—
<i>cordata</i> Lab.	—	—	—	—	—	—	l
<i>gigantea</i> Hook.f.	—	—	f	ld	c	—	—
<i>globulus</i> Lab.	—	—	—	lf	—	—	ld
<i>Johnstoni</i> Maiden.	—	—	c	o	d	—	—
<i>linearis</i> Dehn.	—	—	—	—	—	—	vc
<i>obliqua</i> L'Her.	—	—	—	d	c	—	lc
<i>ovata</i> Lab.	—	—	—	r	—	—	o
<i>regnans</i> F.v.M.	—	—	—	d	r	vr	—
<i>salicifolia</i> (Sol) Cav.	—	—	—	—	—	—	vc
<i>tasmanica</i> Blakely	—	—	—	—	—	—	vc
<i>unialata</i> Baker & Smith	—	—	—	—	—	—	—
<i>urnigera</i> Hook.f.	—	—	d	o	—	—	—
<i>viminalis</i> Lab.	—	—	—	r	—	—	vc
For information regarding the complex hybrid swarms see Brett (1938).							
<i>Leptospermum flavescens</i> Sm.	—	—	—	f	f	—	o
<i>lanigerum</i> Sm.	—	lc	lc	c	r	—	—
<i>rupestre</i> Hook.	vc	o	—	—	—	—	—
<i>scoparium</i> Forst.	—	—	—	o	vc	—	vc
<i>Melaleuca squamea</i> Lab.	—	—	—	—	lc	—	—
Onagraceae							
<i>Epilobium Billardierianum</i> Ser.	—	—	r	o	—	—	—
<i>confertifolium</i> Hook.f.	o	—	—	—	—	—	—
<i>Gunnianum</i> Haush.	o	o	f	f	—	—	—
<i>juncum</i> Forst.	—	—	c	o	o	—	o
Halorrhagidaceae							
* <i>Haloragis depressa</i> (A. Cunn.) Walp.	—	—	—	—	—	—	—
<i>micrantha</i> (R.Br.) Thunb.	r	r	r	—	—	—	—
<i>tetragyna</i> Hook.f.	—	—	—	—	—	—	—
<i>teucroides</i> D.C.	—	r	lc	lc	—	—	—
Umbelliferae							
* <i>Daucus glochidatus</i> (Fisch) Mey.	—	—	—	r	—	—	—
* <i>Eryngium vesiculosum</i> Lab.	—	—	—	—	—	—	—
* <i>Hydrocotyle hirta</i> R.Br.	—	—	—	—	—	—	—
* <i>Orreomyrrhis andicola</i> Endl.	r	—	—	—	—	—	—
* <i>Xanthosia dissecta</i> Hook.f.	—	—	—	—	—	—	—
* <i>pilosa</i> Rudge.	—	—	—	—	—	—	—
Ericaceae							
<i>Gaultheria hispida</i> R.Br.	—	r	c	c	o	o	—
Epacridaceae							
<i>Acrotriche serrulata</i> R.Br.	—	—	—	—	—	—	c
<i>Astroloma humifusum</i> R.Br.	—	—	—	—	—	—	c
<i>Brachyloma daphnoides</i> Benth.	—	—	—	—	—	—	f
<i>Cyathodes acerosa</i> R.Br.	—	o	c	c	o	—	o
<i>adscendens</i> Hook.	vc	c	r	—	—	—	—
<i>dealbata</i> R.Br.	o	—	—	—	—	—	—
<i>divaricata</i> Hook.	—	—	f	—	—	—	o
<i>glauca</i> R.Br.	—	o	c	c	o	—	—
<i>parvifolia</i> R.Br.	—	—	o	c	f	—	o
<i>Epacris impressa</i> Lab.	—	—	—	vc	vc	—	vc
<i>lanuginosa</i> R.Br.	—	—	—	—	r	—	r
<i>microphylla</i> R.Br.	—	—	—	—	r	—	o
<i>serpillifolia</i> R.Br.	f	o	—	—	—	—	—
* var. <i>squarrosa</i>	—	—	—	—	—	—	—
<i>Lissanthe montana</i> R.Br.	o	—	—	—	—	—	—
<i>strigosa</i> R.Br.	—	—	—	—	—	—	c
<i>Monotoca lineata</i> R.Br.	—	—	—	vc	vc	o	—
<i>empetrifolia</i> R.Br.	o	o	—	—	—	—	—

	1	2	3	4	5	6	7
<i>Pentachondra involucrata</i> R.Br.	o	r	vr	—	—	—	—
<i>pumila</i> R.Br.	vc	—	—	—	—	—	—
<i>Richea acerosa</i> F.v.M.	vc	c	—	—	—	—	—
<i>dracophylla</i> R.Br.	—	—	c	r	o	—	—
<i>Gunnii</i> Hook.	c	c	o	—	—	—	—
<i>procera</i> F.v.M.	o	o	o	o	o	—	—
<i>scoparia</i> Hook.	c	c	o	—	—	—	—
<i>sprengeloides</i> F.v.M.	o	o	r	c	c	—	c
<i>Sprengelia incarnata</i> F.v.M.	r	o	r	c	vc	—	vc
<i>Styphelia adscendens</i> R.Br.	—	—	—	—	o	—	—
<i>Trochocarpa thymifolia</i> Spreng.	vc	vc	f	—	—	—	—
Oleaceae							
<i>Notelea ligustrina</i> Vent.	—	—	—	l	—	o	l
Apocyanaceae							
<i>Lyonsia straminea</i> R.Br.	—	—	—	r	—	r	—
Loganiaceae							
<i>Mitrasacme montana</i> Hook.	o	—	—	—	—	—	—
<i>pilosa</i> Lab.	—	—	—	o	—	—	—
Gentianaceae							
<i>Erythraea australis</i> R.Br.	—	—	—	o	—	—	—
<i>Gentiana dimensis</i> Gresb.	f	o	o	o	—	—	—
Boraginaceae							
* <i>Myosotos australis</i> R.Br.	—	—	—	vr	—	—	—
<i>suaveolens</i> Poir.	r	—	—	—	—	—	—
Labiateae							
<i>Prostanthera lasianthos</i> Lab.	—	—	f	vc	—	c	—
I* <i>Stachys arvensis</i> L.	—	—	—	—	—	—	—
<i>Westringia rigida</i> R.Br.	—	—	—	o	—	—	—
Scrophulariaceae							
<i>Euphrasia collina</i> Hook.	—	—	—	f	—	—	c
var. <i>alpina</i> R.Br.	vc	c	c	—	—	—	—
var. <i>striata</i> R.Br.	—	o	o	o	—	—	—
<i>scabra</i> R.Br.	—	—	—	—	—	—	o
* <i>Mazus pumilo</i> R.Br.	—	—	—	—	—	—	—
* <i>Ourisia integrifolia</i> R.Br.	—	—	—	—	—	—	—
I* <i>Veronica agrestis</i> L.	—	—	—	—	—	—	—
I <i>arvensis</i> L.	—	—	—	—	—	—	r
<i>formosa</i> R.Br.	—	r	c	c	—	—	f
<i>nivea</i> Lindl.	r	r	r	—	—	—	—
* <i>gracilis</i> R.Br.	—	—	—	—	—	—	r
I* <i>serpillifolia</i>	—	—	—	—	—	—	—
Plantaginaceae							
* <i>Plantago lanceolata</i> Linn.	—	—	—	c	—	—	c
<i>tasmanica</i> Hook.f.	o	—	—	—	—	—	—
<i>varia</i> R.Br.	—	—	—	o	—	—	d
Rubiaceae							
* <i>Asperula oligantha</i> F.v.M.	—	—	r	c	—	c	o
<i>Coprosma Billardieri</i> Hook.f.	—	—	o	c	—	—	o
<i>hirtella</i> Lab.	—	—	—	—	—	—	—
<i>nitida</i> Hook.	f	c	c	—	—	—	—
<i>Moorci</i> Rodway	r	—	—	—	l	—	—
* <i>repens</i> Hook.	—	—	—	—	—	—	—
* <i>Opercularia varia</i> Hook.	—	—	—	—	—	—	r
Campanulaceae							
<i>Lobelia gibbosa</i> Lab.	—	—	—	—	—	—	r
<i>Whalenbergia gracilis</i> D.C.	—	—	—	o	—	—	l
<i>saxicola</i> D.C.	o	—	—	—	—	—	—

	1	2	3	4	5	6	7
Goodeniaceae							
<i>Goodenia geniculata</i> R.Br.	—	—	—	o	—	—	f
<i>ovata</i> Sm.	—	—	—	c	o	c	—
<i>Scaevola Hookeri</i> F.v.M.	r	—	—	—	—	—	—
Candolleaceae							
<i>Stylidium graminifolium</i> Swartz.	o	—	r	f	c	—	c
Compositae							
<i>Abrotanella Fosterioides</i> Hook.	o	—	—	—	—	—	—
<i>Brachycome melanocarpa</i> Sand. & F.v.M.	—	—	—	—	—	—	r
* <i>stipitata</i> Hook.	—	—	—	—	—	—	o
<i>Cassinia aculeata</i> R.Br.	—	—	—	o	—	—	o
<i>Celmisia longifolia</i> D.C.	vc	c	—	—	—	—	—
<i>Cotula filicula</i> Hook.f.	r	—	—	—	—	—	—
<i>Craspedia alpina</i> Hook.	vc	—	—	—	—	—	—
<i>uniflora</i> Forst.	—	—	—	—	—	—	o
* <i>Cymbonotus Lawsoniana</i> Gaud.	—	—	—	—	—	—	r
<i>Bedfordia linearis</i> D.C.	—	—	—	—	—	—	vc
<i>salicina</i> D.C.	—	—	f	vc	o	d	l
<i>Erechtites arguta</i> D.C.	—	—	—	r	—	—	—
<i>Gunnii</i> Hook.	o	r	—	—	—	—	—
<i>prenanthoides</i> D.C.	—	—	—	r	—	—	—
<i>Erigeron pappochroma</i> Lab.	o	r	—	—	—	—	—
<i>Gnaphalium alpinum</i> F.v.M.	r	r	—	—	—	—	—
<i>indutum</i> Hook.f.	—	—	—	r	r	—	—
<i>Helichrysum apiculatum</i> D.C.	c	o	o	o	o	—	c
<i>dealbata</i> Lab.	—	—	—	—	—	—	r
<i>scorpioides</i> Lab.	c	o	o	c	o	—	c
<i>semipapposum</i> D.C.	—	—	—	—	—	—	—
<i>Lagenophora stipitata</i> Druce.	—	—	—	—	—	—	r
* <i>Leptorrhynchus linearis</i> Less.	—	—	—	—	—	—	r
* <i>squamatus</i> Less.	—	—	—	—	—	—	r
<i>Microseris Fosteri</i> Hook.	—	—	—	r	—	—	r
* <i>Millotia tenuifolia</i> Cass.	—	—	—	—	—	—	o
<i>Olearia argophylla</i> F.v.M.	—	—	—	vc	r	d	—
* <i>erubescens</i> Dipp.	—	—	—	—	—	—	—
<i>floribunda</i> Benth.	o	r	r	c	o	—	f
<i>glandulosa</i> Benth.	—	—	—	—	—	—	—
<i>Hookeri</i> Benth.	—	—	—	—	—	—	o
<i>ledifolia</i> Benth.	o	o	—	—	—	—	—
<i>lepidophylla</i> Benth.	r	vr	—	—	—	—	—
<i>myrsinoides</i> F.v.M.	—	—	r	f	o	—	o
<i>obcordata</i> Benth.	o	—	—	—	—	—	—
<i>persoonoides</i> Benth.	—	—	—	—	—	—	—
var. <i>alpina</i>	o	o	r	—	—	—	—
var. <i>lanceolata</i>	—	—	c	o	—	—	—
<i>pinifolia</i> Benth.	o	f	o	—	—	—	—
<i>ramulosa</i> Benth.	—	—	r	f	—	—	—
<i>stellulata</i> Benth.	—	f	vc	c	o	o	o
<i>viscosa</i> Benth.	—	—	o	f	o	—	f
<i>Ozothamnus antennaria</i> Hook.	o	o	o	—	—	—	—
<i>Backhousii</i> Hook.	o	r	—	—	—	—	—
* <i>ericifolius</i> Hook.	—	—	—	—	—	—	r
<i>Hookeri</i> Hook.	f	—	—	—	—	—	—
<i>ledifolius</i> Hook.	vc	f	r	—	—	—	—
<i>obcordatus</i> D.C.	—	—	—	—	—	—	f
<i>rosmarinifolius</i> D.C.	—	—	—	c	o	f	o
<i>scutellifolius</i> Hook.	—	—	—	—	—	—	r
<i>Gunnii</i> Hook.	r	—	—	—	—	—	—
* <i>Podolepis acuminata</i> R.Br.	—	—	—	—	—	—	r
<i>Raoulia planchonii</i> Hook.	r	—	—	—	—	—	—
<i>Senecio centropappus</i> F.v.M.	—	—	f	—	—	—	—
<i>dryadens</i> Sieb.	—	—	—	c	f	o	f
<i>lautus</i> Sol.	—	—	—	o	—	o	o

	1	2	3	4	5	6	7
* <i>Senecio</i> var. <i>capillifolius</i>	—	—	—	o	—	o	o
var. <i>octoleucus</i>	f	o	o	o	—	—	—
<i>velleyoides</i> A. Cunn.	—	—	—	o	—	—	—
<i>Vittadinia australis</i> D.C.	—	—	—	—	—	—	o

INTRODUCED

<i>Anthemis nobilis</i> L.	? <i>Gnaphalium luteo-album</i> D.C.
<i>Bellis perennis</i> L.	<i>Hypochaeris glabra</i> L.
<i>Calendula officinalis</i> L.	<i>Lapsana communis</i> L.
<i>Carduus arvensis</i> Scop.	<i>Pieris hieraciodes</i> L.
<i>Centipeda minima</i> (L.) Br. & Asch.	<i>Sonchus oleraceus</i> L.
<i>Chrysanthemum parthenium</i> Pers.	<i>Taraxicum dens-leonis</i> Desf.

CONIFERAE

	1	2	3	4	5	6	7
<i>Phyllocladus rhomboidialis</i> Rich.	—	—	vr	—	—	—	—
<i>Podocarpus alpina</i> R.Br.	lc	—	—	—	—	—	—

PTERIDOPHYTA

Lycopodiaceae

<i>Lycopodium clavatum</i>							
var. <i>fastigiatum</i> L.	f	f	f	—	—	—	—
<i>densum</i> Lab.	o	—	—	—	—	f	—
<i>laterale</i> R.Br.	f	r	r	—	—	r	—
<i>scariosum</i> Forst.	r	—	—	—	—	r	—
* <i>selago</i> L.	—	r	r	r	—	r	—
* <i>varium</i> R.Br.	r	—	—	—	—	—	—

Selaginellaceae

<i>Selaginella uliginosa</i> Spreng.	f	o	—	—	—	—	—
---	---	---	---	---	---	---	---

Psilotaceae

<i>Tmesipteris tannensis</i> Bernh.	—	—	—	—	—	o	—
--	---	---	---	---	---	---	---

Ophioglossaceae

* <i>Ophioglossum lusitanicum</i> L.	—	—	—	—	—	—	vr
---	---	---	---	---	---	---	----

Osmundaceae

* <i>Todea barbara</i> (L.) Moore.							
---	--	--	--	--	--	--	--

Schizeaceae

<i>Schizea bifida</i> Willd.	—	—	—	r	r	—	—
* <i>fistulosa</i> Lab.	—	—	—	—	—	—	—

Gleicheniaceae

* <i>Gleichenia circinata</i> Sw.							
<i>dicarpa</i> R.Br.	vc	c	o	o	—	o	—
* <i>flabellata</i> R.Br.	—	—	vr	vr	—	—	—

Hymenophyllaceae

<i>Hymenophyllum australis</i> Willd.	—	—	—	—	—	c	—
<i>flabellatum</i> Lab.	vr	—	—	—	—	c	—
<i>javanicum</i> Spreng.	—	—	—	—	—	o	—
* <i>peltatum</i> (Poir.) Dext.	—	—	—	—	—	—	—
* <i>rarum</i>	—	—	—	—	—	o	—
<i>tunbrigense</i> (L.) Sm.	—	—	—	—	—	r	—

Dicksoniaceae

* <i>Alsophila australis</i> R.Br.	—	—	—	vr	—	vr	—
<i>Dicksonia antarctica</i> Lab.	—	—	—	c	—	vc	—
<i>Hypolepis punctata</i> (Thunb.) Mett.	—	—	—	c	—	vc	—
<i>tenuifolia</i> (Forst.) Bern.	—	—	—	r	—	o	—

Polypodiaceae	1	2	3	4	5	6	7
<i>Adiantum aethiopicum</i> L.	—	—	—	r	—	—	r
<i>Anogramma leptophylla</i> (L.) Link.	r	—	—	vr	—	—	—
<i>Asplenium bulbiferum</i> Forst.	—	—	—	o	—	c	—
<i>flabellifolium</i> Cav.	—	—	r	o	—	c	o
<i>flaccidum</i> Forst.	—	—	—	—	—	o	—
<i>Blechnum capense</i> (L.) Schlecht.	—	—	o	vc	c	vc	—
<i>discolor</i> (Forst.) Keys.	—	—	—	vc	—	c	—
<i>fluviale</i> (R.Br.) Lett.	—	—	—	r	—	r	—
<i>lanceolatum</i> (R.Br.) Sturn.	—	—	—	c	—	c	—
<i>Patersoni</i> (R.Br.) Mett.	—	—	—	—	—	o	—
<i>penna-marina</i> (Poir.) Kuhn.	o	o	o	—	—	—	—
* <i>vulcania</i> (Blume.)	—	—	—	r	—	—	—
<i>Chielanthes tenuifolia</i> (Burm) Sw.	—	—	—	—	—	—	o
<i>Doodia caudata</i> (Cav.) R.Br.	—	r	r	—	—	—	—
<i>Doryopteris decomposita</i> (R.Br.) Kuntz.	—	—	—	vr	—	r	—
<i>Histopteris incisa</i> (Thunb.) Sm.	—	—	—	c	—	c	—
<i>Lindsaya linearis</i> Sw.	—	—	—	vr	vr	—	vr
* <i>Pellaea falcata</i> (R.Br.) Fée.	—	—	—	vr	—	—	—
<i>Pleopeltis diversifolia</i> (Willd.) Melvaine	—	—	f	vc	—	vc	—
<i>Pleurosorus rutifolius</i> (R.Br.) Fée	vr	r	r	o	—	o	—
<i>Polyposium Billardieri</i> (Willd.) C.Ch.	—	—	—	c	—	c	—
<i>gramitidis</i> R.Br.	—	—	—	r	—	o	—
<i>Pteridium aquilinum</i> (L.) Kuhn.	—	—	lc	—	—	—	lc
* <i>Pteris comans</i> Forst.	—	—	—	—	—	—	—
* <i>tremula</i> R.Br.	—	—	—	—	—	—	—
<i>Polystichum aculeatum</i> (L.) Schott.	o	o	o	c	—	c	—
<i>adiantiforme</i> Schott.	—	—	—	r	—	f	—

PLATE XIV

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FIG. 1.—General view of Mt. Wellington looking west.

FIG. 2.—Aerial view of north side of mountain under snow showing the open character of the *E. coccifera* and *E. coccifera-urnigera* associations above compared with the denser *E. obliqua-regnans* below. (Photog. J. J. N. Barnett.)

FIG. 3.—Aerial view of summit of Mt. Wellington showing shrubberies of Austral-Montane Formation and the rocky nature of the ground. (Photog. J. J. N. Barnett.)

FIG. 4.—Aerial view of top of Mt. Wellington plateau under light snow showing the distribution of the *E. coccifera* consociation (dark) on the better drained portions and the Austral-Montane (snow covered) on the flatter portions. The dark isolated patch in the upper right hand quarter is the "nunatak" Dead Island. (Photog. J. J. N. Barnett.)

FIG. 5.—*E. coccifera* consociation, general appearance showing the very rocky ground.

FIG. 6.—*E. coccifera* consociation wetter phase showing *Nothofagus Cunninghami* as a tall shrub.

FIG. 7.—*E. coccifera* as a shrub 3 feet high towards the edge of the plateau.

FIG. 8.—*Poa caespitosa* grassland with scattered *Ozothamnus ledifolius*.



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PLATE XV

- FIG. 1.—General view of the swamp community with the "nunatak" Dead Island in the background.
- FIG. 2.—Swamp-shrubby ecotone showing *Baeckia Gunniana*, *Astelia alpina* and *Ozothamnus ledifolius* (shrub).
- FIG. 3.—Swamp-*E. coccifera* ecotone, *Astelia alpina*, *Poa caespitosa* and *Richea procera* in foreground.
- FIG. 4.—Area of swamp-community within *E. coccifera* consociation. Mixture of *Baeckia Gunniana* and *Gleichenia dicarpa* in the foreground.
- FIG. 5.—*Abrotanella Fosteriodes* invaded by herb species.
- FIG. 6.—*Abrotanella Fosteriodes*, old plant in swamp-grassland ecotone nearly completely covered. The shrub in the centre is *Richea Gunnii*.
- FIG. 7.—Old *E. coccifera* tree (relict) with *E. urnigera* saplings.
- FIG. 8.—*Leptospermum rupestre*, in shrub community near the summit.



1



2



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PLATE XVI

- FIG. 1.—*E. obliqua-regnans* association, *E. obliqua* society. Shrub layer denuded by repeated fires.
- FIG. 2.—*E. obliqua-regnans* association, *E. regnans* society, showing tall shrub layer of *Pomaderris apetala* and *Olearia argophylla*, etc.
- FIG. 3.—“Gully community” in *E. obliqua-regnans* association (in background). Lower altitude type.
- FIG. 4.—Interior of “gully community” higher altitude type. The tree on the left is *Nothofagus Cunninghami* while *Atherosperma moschata* leaves may be seen on the extreme right of the picture. *Dicksonia antarctica* in the foreground.
- FIG. 5.—*E. coccifera-urnigera* association showing *E. urnigera*: *Olearia stellulata* in the foreground *Richea dracophylla* in middle distance and *E. urnigera* sapling socies in the background.
- FIG. 6.—Interior of “gully community” in Fig. 3. above showing stems of *Olearia argophylla* and ferns (*Pleopeltis diversifolia*) and *Blechnum* sp. in foreground.
- FIG. 7.—Aerial view of Snake Plains. Upper left hand corner regenerating *E. urnigera* and *E. Johnstoni* on dolerite talus covering the sandstone of the Plains; lower right hand corner *E. obliqua-regnans* forest on intrusive dolerite mass. Observe the sharply defined ecotone between the swamp and forest vegetation; also the white tops of the dead trees rising above the regenerating forest.
- FIG. 8.—*E. obliqua-regnans* association showing *E. obliqua* and tall shrub layer.
- FIG. 9.—Aerial photograph of lower ridges showing the marked contrast between the open forest of the N.W. side of the ridge and *E. globulus* community on the sheltered side.



1



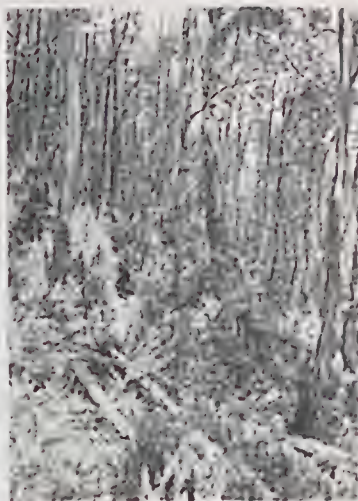
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9

The Toxopidae, a new Family of Spiders

By

V. V. HICKMAN, D.Sc.

(Read 13th Nov., 1939)

PLATES XVII, XVIII, XIX

The present paper is a contribution to the work of the Tasmanian Biological Survey, and deals with a new spider, *Toxops montanus*, from the summit of Mt. Wellington. The characters of the spider seem to justify the establishment of a new family, for which the name Toxopidae is suggested.

Order ARANEAE

Sub-order DIPNEUMONOMORPHAE

Branch TRIONYCHAE

TOXOPIDAE, fam. nov.

Cribellum and calamistrum lacking. Colulus present. Six spinnerets, anterior pair larger than the others. Chelicerae with a scopula and lateral condyle. Both margins toothed. Labium free. Maxillae slightly converging and furnished with a scopula. Legs laterigrade and without scopulae. Trochanters not notched. A distinct pretarsus present. Three tarsal claws. Upper claws pectinate in a single row, similar in male, dissimilar in female. A tarsal pulvillus consisting of a pair of large tenent hairs present. Spurious claws wanting. Trichobothria in two rows on tibiae, in one on metatarsi and in an irregular row on tarsi. Integument with barbed hairs. Eight eyes, which, when viewed from above, form a recurved row. Posterior lateral eyes very large. One pair of book-lungs in normal position. A single tracheal spiracle close to spinnerets. Tracheal system extending into the cephalothorax and its appendages. Pedipalp of female with a straight non-pectinate claw.

Toxops, gen. nov.

Carapace as in *Xysticus*. Eight eyes in a recurved row. PLE very large. PME minute and in front of PLE. Clypeus narrow. Furrow of chelicerae oblique, promargin with one conical tooth and a bicuspid tooth, retromargin with three teeth. Labium wider than long, reaching slightly beyond middle of maxillae. Sternum shield-shaped, as wide as long. Legs 4.2.3.1. in male. Spines on femora, tibiae and metatarsi, but none on tarsi.

Genotype.—*Toxops montanus*, sp. nov.

Toxops montanus, sp. nov.

(Plates XVII, XVIII, XIX)

Male.—Measurements in millimetres:—

Total length	2.78
Length of cephalothorax	1.22
Width of cephalothorax	1.16
Length of abdomen	1.56
Width of abdomen	1.04

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	1.10	0.46	0.87	0.75	0.52	3.70
2	1.27	0.46	0.98	0.81	0.52	4.04
3	1.22	0.46	0.93	0.81	0.52	3.94
4	1.22	0.46	0.98	0.93	0.52	4.11

Colour.—Carapace light brown with black lateral margins and a wide dark brown band on each side, extending from PLE to the posterior margin. Legs, palpi, chelicerae, sternum and maxillae light brown. Labium dark brown. Dorsal surface of abdomen brown with a median longitudinal dark-brown mark anteriorly, followed by three or four pairs of dark brown spots, which tend to form chevrons towards posterior end.

Carapace.—Nearly as wide as long. Head part flat. The thoracic groove longitudinal, its front end being on a level with the posterior margin of the PLE. Posterior declivity steep and much shorter than the flat portion of the carapace. There is a slender bristle on each side of the thoracic groove. The flat part of carapace is lightly clothed with white barbed hairs, while at the sides, in front and on the lateral margins, are a few black setae. The form of the carapace resembles that of the female (Pl. XVIII, figs. 5 and 6).

Eyes.—Viewed from above the eight eyes form a recurved row (Pl. XVIII, fig. 5). The PLE are very large and mounted on conspicuous black tubercles. The PME are minute and in front of the PLE. The eye ratio AME:ALE:PME:PLE = 12:15:7.5:24. The AME are separated from each other by about 16/12 of their diameter; from ALE by 14/12 of their diameter. The ALE are separated from PME by a space equal to 9/12 of the diameter of AME. The PLE are separated from ALE and from PME by a space equal to 18/12 of the diameter of AME. Viewed from in front the ALE are at a higher level than the AME (Pl. XVIII, fig. 7). The clypeus is 15/12 of the diameter of AME.

Chelicerae.—Conical, 0.46 mm. long. Clothed in front with a few hairs. A small lateral condyle is present. Furrow oblique. Promargin armed with a small conical tooth and a large bicuspid tooth (Pl. XVIII, fig. 13). Retromargin armed with three teeth, that nearest the base of fang being the largest. A scopula consisting of 5 or 6 barbed hairs is present on the promargin and a very long barbed hair on each side near base of fang.

Maxillae.—Slightly converging, 0.35 mm. long. Outer angle rounded. Serrula long, reaching outer angle. Scopula as shown in Pl. XIX, fig. 17.

Labium.—Wider than long in ratio 3:2. Apex truncate, reaching slightly beyond the middle of maxillae.

Sternum.—Shield-shape, slightly convex, as wide as long, ending in a point, which separates the fourth coxae. Lightly clothed with black hairs (Pl. XIX, fig. 17).

Legs.—4.2.3.1. Coxae cylindrical. The podomeres are clothed with barbed hairs. About eight trichobothria arranged in two rows on each tibia, three in a single row on each metatarsus, and three in an irregular row on each tarsus. The trichobothria increase in length towards the apex of the segment. Each leg has a distinct pretarsus carrying three tarsal claws. The superior claws are pectinate, the inferior claw smooth. In the first pair of legs the pro-claw has six blunt teeth, the retro-claw six blunt teeth and one small sharp tooth near the base (Pl. XVIII, fig. 11). In the other legs the claws are similar but with only five teeth. A scopula is lacking. Claw-tufts, however, are represented by a pair of large club-shaped tenent hairs. These tenent hairs form a kind of pulvillus, resembling that in *Apostenus fuscus* Westr. (Simon 1897, p. 137, fig. 145). Except for a difference in the pectination of the claws, the pretarsus of the male resembles that of the female (Pl. XVIII, fig. 8).

Palpi.—The form of the right palpus is shown in Pl. XVIII, figs. 9 and 10. The podomeres have the following lengths in mm:—Femur 0.406, patella 0.232, tibia 0.30, tarsus 0.64. The copulatory apparatus consists of a flat sickle-shaped translucent conductor, which, extending beyond the margin of the tarsus, curves round the apex and prolateral side. The tip rests against the ventral surface of the tibia. The embolus makes one complete turn in an opposite direction to that of the conductor. On the dorsal side the tarsus is furnished with a large basal excavation, within which the surface is finely granulate. The tibia is broad and somewhat dorso-ventrally compressed. On its dorsal surface near the apex is a large curved apophysis, which projects into the excavation on the tarsus. Two other apophyses are present on the retro-lateral side of the tibia near the apex. Three trichobothria are arranged in a triangular group on the dorsal surface of the tibia.

Spines.—*First leg*.—Femur: dorsal 1-1, prolateral 1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 1, retrolateral 1, ventral 2-2-0. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0. *Second leg*.—Femur: dorsal 1-1, prolateral 1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 0, retrolateral 1, ventral 2-2-0. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0. *Third leg*.—Femur: dorsal 1-1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 0, retrolateral 1, ventral 2-2-0. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0. *Fourth leg*.—Femur: dorsal 1-1, elsewhere 0. Patella: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 0, retrolateral 1, ventral 2-2-1. Metatarsus: dorsal 1, prolateral 0, retrolateral 0, ventral 2-2-2. Tarsus 0.

Abdomen.—Oval, clothed with recumbent barbed hairs and fine erect bristles. Six spinnerets. The anterior pair are short truncated cones, two-jointed, but the apical joint is very small and difficult to see, except in microscopic preparations. The other spinnerets are much smaller than the anterior pair, and in ventral view are hidden by the latter. There is a small colulus immediately in front of the anterior spinnerets.

Female.—Measurements in millimetres:—

Female.—Measurements in millimetres.							
Total length						2.90	
Length of cephalothorax						1.22	
Width of cephalothorax						1.16	
Length of abdomen						1.74	
Width of abdomen						1.27	
<i>Leg</i>		<i>Femur</i>	<i>Patella</i>	<i>Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
1		0.94	0.48	0.68	0.63	0.44	3.17
2		1.08	0.52	0.75	0.65	0.44	3.44
3		1.01	0.45	0.71	0.63	0.44	3.24
4		0.93	0.38	0.70	0.65	0.44	3.10

The female (Pl. XVII, fig. 1) resembles the male in coloration and general appearance. Hence only the following characters need be described:—

Eyes.—The eight eyes are arranged as shown in Pl. XVIII, figs. 5, 6 and 7. The eye-ratio AME: ALE: PME: PLE = 5:8:2:14. The AME are separated from each other by twice their diameter and from ALE by $7/5$ of their diameter. The ALE are separated from PME by a space equal to $6/5$ of the diameter of AME. The PLE are separated from ALE by twice the diameter of AME and by slightly less than this distance from PME.

Legs.—These are much shorter than those of the male, and the order of the relative lengths is different, being 2.3.1.4. The tarsi end in a pretarsus carrying three claws and a pulvillus (Pl. XVIII, fig. 8). The inferior claw is shorter and blunter than in the male. The superior claws are markedly dissimilar. The pro-claw has ten well-developed teeth, which gradually increase in size towards the apex of the claw. The retro-claw has only one well developed tooth, the others being vestigial (Pl. XVIII, fig. 12).

Trichobothria and spines are arranged as in the male.

Palpi.—The segments have the following lengths in mm:—Femur 0.38, patella 0.22, tibia 0.33, tarsus 0.38. The tarsal claw is straight and smooth. There are five trichobothria on the dorsal side of the tibia, arranged in a prolateral row of 2 and a retrolateral row of 3. None on tarsus. Spines are arranged as follows:—Femur: dorsal 1-1, elsewhere 0. Tibia: dorsal 1-1, prolateral 2-2, retrolateral 1-1, ventral 0. Tarsus: dorsal 1-1, prolateral 2-2-2, retrolateral 2-2-2, ventral 0.

Epigynum.—The form of the epigynum as seen in transparent preparations is shown in Pl. XIX, fig. 14. The spermatheca of each side is a strongly convoluted tube. The convolutions are close to the ventral surface and in most specimens are visible through the integument. The inner surface of the posterior coils is furnished with a number of conical projections.

Locality.—Mount Wellington, Tasmania. 31st May, 1939.

Respiratory System

The respiratory system was studied both in serial sections and in specimens treated with caustic potash solution. One pair of book-lungs is present in the normal position in front of the epigastric furrow. In the adult female each book-lung has 17 leaves.

The tracheal spiracle in front of the spinnerets leads into a shallow atrium. From this two stout trunks pass directly forward below the ventral longitudinal muscles. Just beyond the epigastric furrow each trunk gives rise to a large number of fine tubules which pass through the petiolus into the cephalothorax. In a transverse section through the petiolus of one specimen, nearly two hundred of these tubules could be counted (Pl. XIX, fig. 15). Each leg receives about six tubules. The other tubules penetrate to all parts of the cephalothorax.

The abdomen is supplied with tracheae given off from the sides of the two main trunks. These are well shown in a whole mount of the tracheal system removed from the last exuvium of a specimen which underwent ecdysis in captivity (Plate XVII, fig. 4).

The Heart

No attempt was made to study the circulatory system in detail. The heart, however, was examined in serial sections and also dissected from the abdomen and examined whole. It has three pairs of ostia.

The Thoracenteron

The thoracenteron gives rise to three pairs of lateral caeca, which extend laterally and ventrally ending near the coxae of the second, third and fourth pairs of legs respectively (Pl. XIX, fig. 16). In addition to the lateral caeca there is a median bilobed caecum arising near the junction of the thoracenteron with the sucking stomach and extending forward above the latter.

Habits, Egg-sac and Courtship

Toxops montanus is found on low shrubs, especially the Grass-tree, *Richea scoparia* Hooker, growing on the summit of Mount Wellington. The spider does not spin a web. It runs very quickly and its laterigrade legs enable it to creep between the closely arranged leaves of the Grass-tree. During May, 1939, several mature females, together with immature specimens of both sexes, were collected. These were placed in a small vivarium in the laboratory and provided with small branches from the shrubs on which they were found. The spiders require fairly moist conditions, and it was necessary frequently to sprinkle the vivarium with water.

About the 16th July, 1939, one of the mature females made an egg-sac, which was oval in outline and measured 3.54 mm. long by 2.32 mm. wide. It was closely applied to the upper surface of a leaf of the Grass-tree and was made of pure white silk. The egg-sac was covered with leaf fragments and other debris (Pl. XVII, fig. 3). After about four weeks the sac was opened and found to contain two eggs in process of development. Each egg measured 0.93 mm. long by 0.75 mm. wide. They were not disturbed but allowed to remain in the egg-sac until they hatched. This occurred on 17th September, 1939. The newly-hatched spider underwent its first ecdysis on 6th October, 1939.

Some of the immature males and immature females collected on Mount Wellington were kept until they reached maturity, the two sexes being placed in separate vivaria. A male underwent its final ecdysis on the 17th July, 1939, and a female on the 10th August, 1939. These two spiders were placed together in a glass specimen tube on the 20th August, 1939. The male soon gave signs of sexual excitement and was observed to rub the tarsi of the first pair of legs against the side of the tube. Apart from this, however, there seemed to be very few indications of a preliminary courtship. After repeating the movements of the tarsi several times, the male rushed at the female and copulation occurred. This took place at 1.20 p.m., the spiders adopting the position shown in Pl. XIX, fig. 18. The female remained in a more or less passive state during the whole process, which lasted for more than an hour. Its completion, however, was not observed.

At 7.10 p.m. the male was removed from the tube and another male admitted. Copulation with the latter occurred at 7.20 p.m. and lasted for more than five hours, the spiders being kept under observation until 12.20 a.m. on 21st August, 1939. The male palpi were not employed simultaneously, the left palpus being applied first and then the right.

The female was removed next morning and kept alive in a separate vivarium until 4th November, when she made her first egg-sac. It follows from the above observations that spermatozoa may be stored in the spermatheca of the female for at least 74 days before eggs are laid.

SYSTEMATIC POSITION OF *TOXOPS MONTANUS*

Toxops montanus shows many features possessed by the Agalenidae, but it differs from members of this family in the arrangement of the eyes, the pectination

of the tarsal claws, the presence of a distinct pretarsus and pulvillus and in the tracheal system extending into the cephalothorax.

In being a dipneumone spider having the tracheal spiracle close to the spinnerets and the tracheal system penetrating the cephalothorax, *Toxops montanus* resembles the families Uloboridae, Dictynidae, Micryphantidae, Prodidomidae and Attidae and also the genus *Zodarion*. In other respects it differs widely from these groups.

The arrangement of the eyes approaches that of the Selenopidae.

The peculiar tarsal pulvillus recalls the similar structure in *Apostenus fuscus* Westr., but the latter spider is one of the Clubionidae, and has only two tarsal claws. These, however, like the upper claws of the female of *T. montanus*, are dissimilar.

T. montanus thus possesses characters found in several widely separated families. For these reasons the establishment of the new family, Toxopidae, seems necessary.

The above research was carried out in the Biology Department of the University of Tasmania and under the auspices of the Trustees of the Ralston Bequest.

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PLATE XVII

Toxops montanus, sp. nov.

FIG. 1.—Photograph of female, X 7.

FIG. 2.—Photograph of male, X 7.

FIG. 3.—Photograph of egg-sac on leaf of *Richea scoparia*, X 7.

FIG. 4.—Microphotograph of tracheal tubes removed from the exuvium of the penultimate instar, X 47.



1



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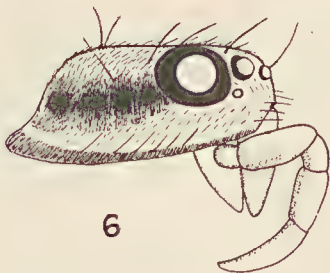
PLATE XVIII

Toxops montanus, sp. nov.

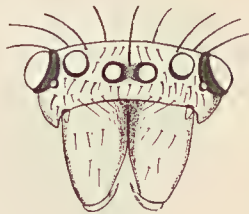
- FIG. 5.—Dorsal view of carapace and eyes, ♀.
FIG. 6.—Lateral view of carapace and eyes, ♀.
FIG. 7.—Front view of face and chelicerae, ♀.
FIG. 8.—End of tarsus showing pretarsus, claws and the two large tenent hairs forming a pulvillus, ♀.
FIG. 9.—Ventral view of right palpus, ♂.
FIG. 10.—Dorsal view of right palpus, ♂.
FIG. 11.—Pectination of tarsal claws, ♂.
FIG. 12.—Pectination of tarsal claws, ♀.
FIG. 13.—Retrolateral view of left chelicera showing bicuspid tooth on promargin, ♂.



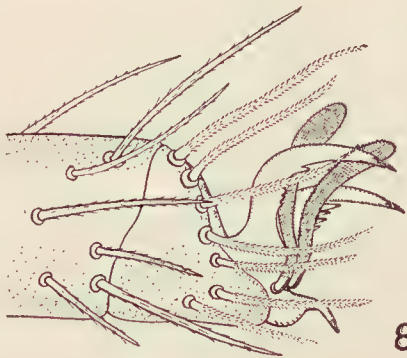
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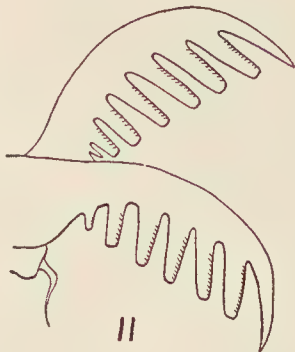
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PLATE XIX

Toxops montanus, sp. nov.

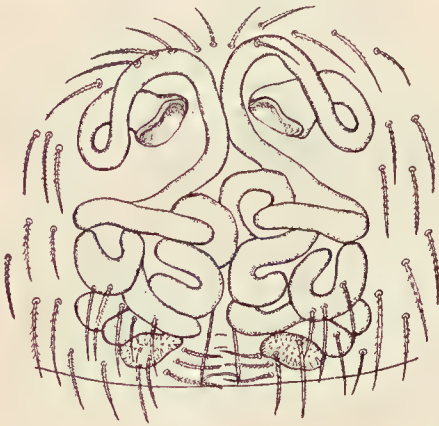
FIG. 14.—Ventral view of epigynum as seen in transparent preparations.

FIG. 15.—Transverse section through petiolus showing the large number of tracheal tubules below the gut, ♀.

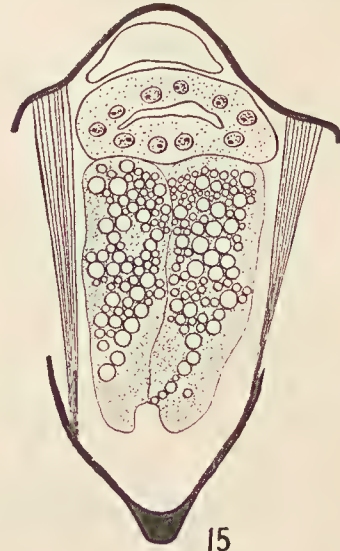
FIG. 16.—Dorsal view of thoracenteron *in situ*, ♀.

FIG. 17.—Sternum, labium and maxillae, ♂.

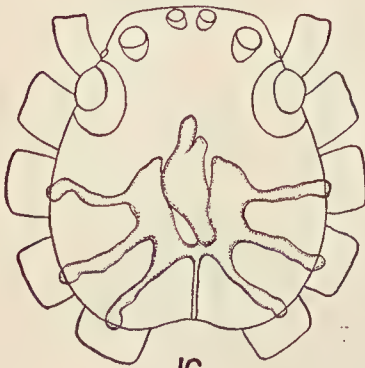
FIG. 18.—Position adopted by male and female in copulation.



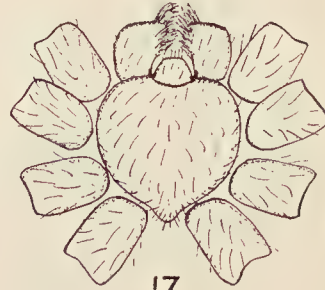
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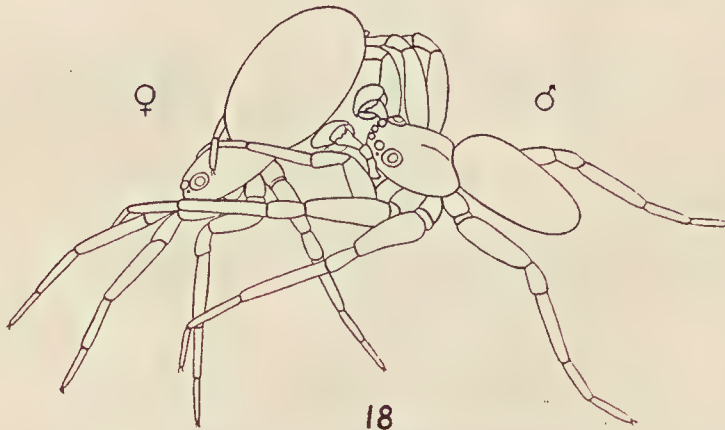
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18

NATIONAL MUSEUM OF VICTORIA

The Royal Society of Tasmania

1939

Patron:

His Majesty the King.

President:

His Excellency Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E.

Vice-Presidents:

W. L. Crowther, D.S.O., M.B., V.D., 1939.

W. H. Clemes, B.A., B.Sc., 1939, 1940.

Council:

V. V. Hickman, B.A., D.Sc., 1939, 1940, 1941.

A. N. Lewis, M.C., LL.D., M.H.A., 1939, 1940, 1941.

E. E. Unwin, M.Sc., 1939, 1940.

H. Allport, LL.B.; 1939, 1940.

J. W. Evans, M.A. (Cantab.), F.R.E.S., 1939.

W. H. Hudspeth, B.A., 1939.

Standing Committee:

W. L. Crowther, A. N. Lewis, V. V. Hickman, J. Pearson.

Hon. Treasurer:

S. Angel.

Hon. Editor.

Joseph Pearson, D.Sc. (Manc.), D.Sc. (Liverpool), F.R.S.E., F.L.S.

Auditor:

Walter E. Taylor, F.F.I.A., F.I.A.S.

Secretary and Librarian:

Joseph Pearson, D.Sc., F.R.S.E., F.L.S.

Annual Report

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 16th February, 1939.

The following Office-bearers were elected:—

Under the Society's Rules Dr. A. N. Lewis retired from the office of Vice-President, and Mr. W. H. Clemes was appointed in his place (retiring 1941).

Treasurer: Mr. S. Angel.

Under the Rules Mr. W. H. Clemes and Professor A. L. McAulay retired from the Council, and the following members of Council were elected in their place:—

Dr. A. N. Lewis (retiring 1942).

Dr. V. V. Hickman (retiring 1942).

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Dr. A. N. Lewis, Mr. W. H. Hudspeth, and the Secretary.

The Council elected the following five Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens:—Mr. W. H. Hudspeth, Mr. W. H. Clemes, Dr. A. N. Lewis, Dr. W. L. Crowther, Mr. J. W. Evans.

Eleven meetings were held during the year (see proceedings for abstract of papers). In addition scientific papers were submitted for publication and have been printed in the present volume.

During 1939 the Tasmanian Museum and Botanical Gardens Act was amended by Parliament so as to alter the representation of the Government and the Royal Society on the Board of Trustees. Previously the Board was composed of nine members as follows:—

Trustees appointed by the Government	2
Trustees appointed by the City Council	2
Trustees appointed by the Royal Society of Tasmania	5

Under the amended Act the representation will be as follows:—

Trustees appointed by the Government	5
Trustees appointed by the City Council	2
Trustees appointed by the Royal Society of Tasmania	2

This amendment will come into force in 1940.

Library

During the year 382 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign countries. The number of Institutions on the Exchange List for the year was 283, being made up of 135 British, 52 American and 96 from other parts of the world. The Library now consists of 19,649 volumes.

The sum of £47 18s. 8d. was spent on books during the year, and the amount was allocated as follows:—

	£	s.	d.
General Fund	22	5	6
R. M. Johnston Fund	17	2	6
Morton Allport Memorial Fund	4	7	3
Beattie Memorial Fund	4	3	5

In addition the Tasmanian Museum spent £4 7s. 7d. on books and the Botanical Gardens £5 11s. 3d. These books have been placed in the Society's Library for safe-keeping, and are available to members.

358 book covers were provided during the year, making a total of 1608.

New Lantern

During the year the Council decided to purchase a new lantern to replace the old one which was unsatisfactory, and an instrument has been obtained which serves three purposes, namely, an ordinary projection lantern with an epidiascope and microscopic attachment.

Membership

The Society consists of the following members:—	1938.	1939.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	7	7
Ordinary Members	232	240
Associate Members		3
Total	244	255

During the year 16 names were removed from the membership owing to deaths, resignations, etc., and 27 new names were added.

The Council regrets having to record the deaths of the following members during the year: Mrs. David Meredith, Hon. L. M. Shoobridge, Mr. L. Morrisby, Mr. F. E. Wallace, Mr. J. B. Scott.

Clive Lord Memorial

At the General Meeting on 17th April the Clive Lord Memorial Prize of £10 was awarded to Mr. R. J. Linford for his essay on "The Customs Tariff and Economic Expansion—A Survey of the Industrial Development of Tasmania during the years 1803 to 1850 and its relation to revenue collections".

On 23rd October Professor J. B. Cleland of the University of Adelaide delivered the second Clive Lord Memorial Lecture on "Some Aspects of the Ecology of the Aboriginal Inhabitants of Tasmania and Southern Australia". His Excellency the Governor presented the Clive Lord Memorial Medal to Professor Cleland.

Printing of Papers and Proceedings

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this generous assistance.

Abstract of Proceedings

16TH FEBRUARY, 1939

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E., presided.

The following were elected Office-bearers and members of the Council for 1939:—Vice-Presidents, Dr. W. L. Crowther (1 year), Mr. W. H. Clemes (2 years); Treasurer, Mr. S. Angel. Council: 3 years, Dr. A. N. Lewis and Dr. V. V. Hickman; 2 years, Mr. E. E. Unwin and Mr. Henry Allport; 1 year, Dr. J. W. Evans and Mr. W. H. Hudspeth.

Mr. Walter W. Taylor was appointed Hon. Auditor.

The following were elected members of the Society:—Dr. C. Craig, Dr. D. H. E. Lines, Mr. A. R. Bull, Mr. O. J. Sternberg, Alderman R. H. Lord.

Dr. F. W. Whitehouse gave an illustrated lecture on 'Experiences of a Geologist in the Field', of which the following is an abstract:—

Dr. Whitehouse explained that a palaeontologist's work was, briefly, the collection and study of fossils. The earth had been in existence about 2,000,000,000 years, and they could trace life back only 600,000,000 years. Before that period it was difficult to correlate things from country to country. This matter, however, was made comparatively easy by the existence of fossils, and it was his job as a palaeontologist to interpret fossils in that way. Persons had been working on those lines for a long while, and had built up an amazing number of facts.

In his main work of correlating the strata from place to place, the palaeontologist unearthed many curious creatures in a fossil state, and had revealed a great wealth of pre-existing floras and faunas, thus adding greatly to the knowledge of evolution. He illustrated this by examples, particularly as they applied to Australia, and to Tasmania. Some of the Tasmanian examples had been found very difficult of correlation with other zones in the world.

Dr. Whitehouse told of his practical experiences in the far west of Queensland, and in the Northern Territory, where he had spent the Summer vacations for the past seven years, and prior to that in the artesian basin of Australia. It was necessary for a palaeontologist to do his own collecting, and there were only four or five to cover the immense area of Australia. He concluded his lecture with a number of lantern slides.

20TH MARCH, 1939

A meeting was held in the Society's Room on this date. Mr. W. H. Hudspeth presided in the absence of the President.

Mr. Hudspeth announced the death of the Hon. L. M. Shoobridge, who had been a member of the Council for some years and mentioned the loss which Mr. Shoobridge would be to the community at large. The Council of the Society had already sent a message of condolence to Mrs. Shoobridge.

The following were elected members of the Society:—Ordinary Members, Mr. J. O. Henrick; Associate Members, Mrs. J. A. McElroy, Mr. R. W. Kerr.

It was announced that the Clive Lord Memorial Prize to the value of £10 had been awarded to Mr. R. J. Linford for his essay on 'The Customs Tariff and Economic Expansion—A Survey of the Industrial Development of Tasmania during the years 1803 to 1850 and its relation to revenue collections', and that the award would be made at the next meeting of the Society.

Dr. A. N. Lewis gave an illustrated lecture on 'Time Scales in recent Tasmanian Geological History', of which the following is an abstract:—

The advance in our knowledge of physiographical geology in the past 15 years has changed our ideas of Tasmanian geology.

At one time Tasmania was much more extensive than at present, was joined to the Mainland and consisted of flat or rolling plains like the Midlands to-day.

The first change was a considerable western uplift which spread along the northern coast to the north east giving a series of mountains at least 4000 feet higher than the original plain. Later these mountains were worn down so as to expose the ancient ore-bearing rocks.

This was followed by an ice age consisting of three phases. After the first glacial phase there was considerable volcanic activity giving large lava flows.

A second uplift caused the central, eastern and southern highlands. This uplift broke the old valleys frozen by the basalt lava flows and in places caused a difference in level of as much as 4000 feet in some valleys.

Next the Bass Strait was formed and considerable areas off the west, south and east coasts were submerged.

All these movements were the result of pressure caused by the sinking of the ocean floor and the consequential squeezing of the southern part of the Australian land mass. The mountains were compensational effects of that pressure. Thus the scenery and geographical features of Tasmania have been produced in relatively recent times. The movements were gradual and are probably still in progress.

17TH APRIL, 1939

A meeting was held in the Society's Room on this date, the President, His Excellency the Governor, presiding.

Mr. Henry Allport was elected to the Council in place of the late Hon. L. M. Shoobridge.

The following were elected members of the Society:—Mr. L. Cerutti, Mr. G. C. Israel.

The Clive Lord Memorial Prize was presented to Mr. R. J. Linford.

Short illustrated notes on biological subjects were given as follows:—

Professor A. L. McAulay gave a paper on 'Saltants of a fungus produced by ultra-violet rays', illustrated by lantern slides.

Dr. V. V. Hickman showed a specimen of the Pouched Lamprey, *Geotria australis* Gray, which occurs in Australia, New Zealand and South America.

A specimen from Tasmania was described under the name *Geotria allporti* by Gunther in 1871. F. G. Maskell (*Trans. Proc. N.Z. Inst.*, Vol. 60, 1929) has shown that, after hatching, *Geotria australis* passes through four well marked stages in its development, namely, the Ammocoetes stage, the Macrophthalmia stage, the Velasia stage and finally the adult or sexually mature stage. These developmental forms are so different that for a number of years they were regarded as distinct species. The large gular pouch is well developed only in the male, the female often showing no signs of a pouch. The Velasia stage is spent at sea and there is some evidence that, on returning, the lamprey enters Tasmanian rivers in May or June.

Dr. H. D. Gordon exhibited several specimens of the 'Native Bread'—*Polyporus mylittae*.

Dr. Gordon exhibited several specimens of the 'Native Bread'—*Polyporus mylittae*, including one which he had recently received from Dr. R. A. Scott of the Department of Agriculture, Launceston, and which showed an unusually prolific growth of the mushroom-like reproductive structures or sporophores. He explained that the so-called 'bread' was a sclerotium, a dense mass of fungus tissue in which food material is stored, to be used up later as the sporophores develop. This habit could be compared with that of many flowering plants which store food in a bulb or tuber and use it up later in the rapid development of leaves and flowers.

Dr. Gordon also exhibited a specimen of a moth caterpillar parasitised by the fungus *Cordyceps*, and explained that in this case the fungus assimilated all the internal tissues of the caterpillar, which were replaced by dense fungus tissue, the outer layers alone persisting unchanged, thus a sclerotium was formed retaining the appearance of the caterpillar, and from this sclerotium the visible spore-bearing part of the fungus developed.

Mr. R. G. Brett discussed the identification of Eucalypts in the Field.

He pointed out that the difficulties in identification of Eucalypts in the field arise from a failure to recognize the nature of an average Eucalypt population. In general the following components are present:—

- (a) Species exhibiting marked variability.
- (b) Interspecific hybrids and their segregating progeny.
- (c) Polymorphs.
- (d) Inter-polymorph-specific hybrids and their progeny.

The term polymorph was defined as a member of a population derived from two or more species but showing strongly the character of one, e.g., *xE. risdelata* derived from *E. risdoni* Hook., f. and allied species by hybridization. Polymorph populations exhibit varying degrees of fixation and in some cases approach that of a true species.

The types were illustrated from Tasmanian and Extra-Tasmanian collections in the form of photographs and seedling trees.

The question of a suitable terminology was discussed.

A short account of the principal insects that attack oak trees in Tasmania was given by Mr. J. W. Evans. The black deposit found so commonly on these trees is a secondary effect resulting from the growth of a sooty-mould fungus on the excreta of the oak-scale and the oak aphid. In conclusion the lecturer stated that, as the result of the activity of insect parasites of the scale and the aphid, the health of oak trees was steadily improving.

Dr. Pearson laid on the table an *Astraeid* coral, specimens of which had been found washed up on the northern shores of Tasmania. A specimen had also been found at Dover. The evidence pointed to the fact that this coral was living in Tasmanian waters, in itself a remarkable thing as *Astraeid* corals had not hitherto been found so far away from the tropics, so far as Dr. Pearson was aware.

8TH MAY, 1939

A meeting was held in the Society's Room on this date, the President, His Excellency the Governor, presiding.

Dr. Pearson brought to the notice of the Society the discovery in South African waters of a living *Coelacanthid* fish belonging to a group of *Crossopterygian* fishes which had hitherto been regarded as extinct.

The last recorded *Coelacanthid* fossil occurred in the Upper Cretaceous Age and so this discovery of a living member of the group was of the highest zoological interest and of supreme importance. Dr. Pearson recalled the discovery of the Tasmanian crustacean *Anaspides* in 1893, which bridged an even greater gap, as the relatives of this form had been regarded as having died out as early as carboniferous times. It was perhaps understandable that a relatively small animal such as *Anaspides* should have escaped the notice of observers for nearly a century after Tasmania was colonized by civilized men but it was amazing that a large living *Coelacanthid* fish should have evaded discovery.

Dr. J. W. Evans gave an account of *Aquatic Insects*.

Before dealing with the different groups of aquatic insects, mention was made of the pioneer workers who had investigated the life-history of a number of water insects. These were Reamur, Swammerdam, Lyonnet and de Geer. Structural adaptations that enable insects to live in water were discussed, especially those concerned with breathing, and in relation to the surface film. Examples of the principal groups of water-living insects were dealt with, and attention drawn to the wide range of conditions afforded by an aquatic medium. The lecture was illustrated by drawings and photographs and several live water insects exhibited.

5TH JUNE, 1939

A meeting was held in the Society's Room. His Excellency the Governor presided. The following members were elected:—Ordinary, Professor E. R. Walker, Mr. H. J. Read; Associate, Mr. S. C. Morris.

Mrs. J. A. McElroy gave a paper on Dr. Joseph Milligan and some early records of the Royal Society of Tasmania.

This paper gave a brief biographical sketch, and an account of Dr. Milligan's activities as Secretary of the Royal Society from 1848 to 1860. It described many objects donated to the Museum when it occupied the premises at the corner of Harrington and Macquarie Streets, and also the development and products of the Botanical Gardens.

Mr. W. E. Masters gave a lecture on 'Free Immigration in the 1820's'.

10TH JULY, 1939

A meeting was held in the Society's Room. In the absence of the President, Mr. W. H. Hudspeth presided.

The following members were elected:—Dr. A. B. Edwards, Mr. J. E. Cuthbertson. Professor E. Ronald Walker gave a lecture on the economic background of the European situation. The lecture was illustrated by maps.

He pointed out that in studying the present situation in Europe we must recognise that leaders and parties can determine the course of events, only within certain limits imposed by economic conditions.

Behind the spectacular moves of politics certain fundamental economic pressures are operating which may prove to be more important in the long run than strokes of policy. For instance the population balance of Europe is changing. Of the expected increase of 100 million between 1930 and 1960, no less than 75 million will be in Eastern Europe and 15 million in Mediterranean countries. Central Europe will expand very slowly, while the populations of the West and North will stagnate. This shift in population complicates the relationships between rural and industrial Europe. In Eastern Europe there is chronic over-population of the rural areas, which used to be relieved by overseas emigration, but now can only be absorbed and supported by the industrialization of backward regions of Europe. The poverty of these Eastern countries prevents accumulation of the capital which is necessary for their industrialization. Consequently the future depends upon co-operation with the Western industrial powers which have capital available for investment. One obstacle to this co-operation is the desire of the industrial interests to preserve Eastern Europe as a market for Western manufactures and as a source of raw materials for Western industry.

Europe's problems cannot be solved by the piecemeal efforts of separate States, each insisting on its own sovereignty. Planning on a continental scale is needed. But European sentiment lags behind the facts of European economic unity. The Western democracies, Britain and France, have one foot in Europe and the other overseas; and Germany is obsessed by the delusion of racial supremacy. The other European powers are too small or too weak to play a dominant role in the reorganisation of Europe's economic life which is a necessary condition for the survival of European civilization.

Germany's leaders are bent on solving the European problem by dominating Central and Eastern Europe. Economically this implies the exploitation of the outlying states rather than their industrialization and does not promise a solution of their agrarian problems.

Both Germany and Italy back their diplomacy with the threat of a 'lightning war', but a war of attrition is more likely. In such a war the balance of economic strength would not be in Germany's favour.

14TH AUGUST, 1939

A meeting was held in the Society's Room. In the absence of the President Mr. W. H. Hudspeth presided.

The following members were elected:—Mr. A. F. Ryan, Mr. G. K. Meldrum, Mr. W. S. Manson, Mr. G. H. Crawford, Mr. J. A. Dumaesq, Dr. B. A. Anderson, Mr. R. G. Hall, Miss G. M. F. Brown.

Dr F. P. Bowden gave a lecture on 'Polishing and the sliding of Ski' of which the following is an abstract:—

1. *The Mechanism of Polishing*

The process of polishing is greatly influenced by the relative melting point of the polisher and the solid. The relative hardness is comparatively unimportant. Experiment shows that surface flow is brought about by an intense local heating of the surface irregularities to the

melting or softening point. The molten or softened solid flows or is smeared over the surface and very quickly solidifies to form the polished Beilby layer. These local high temperatures also play an important part in the wear and corrosion of sliding surfaces.

2. *The Sliding of Ski*

An experimental investigation is made of the experimental laws which govern the friction of solids sliding on ice and snow. The static friction is considerably higher than the kinetic friction. Within certain limits, the coefficient of kinetic friction is independent of the load, apparent area of contact and the speed of sliding. The kinetic friction on ice, at temperatures near the melting point, is very small but it increases as the temperature falls and at low temperatures reaches a value comparable with that observed on other crystalline solids. The friction is greatly influenced by the thermal conductivity of the sliding surface.

There is evidence that the low friction is due to the local formation of a thin water film at the points of sliding contact. The results suggest that, although pressure melting may play some part, the low friction observed for rapidly moving solids is due largely to melting by frictional heat.

Experiments with miniature and real ski on snow show that the same general laws are obeyed as on ice. The higher friction on snow is attributed to the extra work of displacing and compressing the snow crystals.

· 11TH SEPTEMBER, 1939

A meeting was held in the Society's Room. In the absence of the President Dr. W. L. Crowther presided.

The following members were elected:—Mr. A. Flach, Dr. W. P. Holman.

The subject of 'Inheritance of Visual Defects' was dealt with by Dr. J. Bruce Hamilton and Dr. J. Pearson.

Dr. Pearson explained the principles of genetics and the mechanism of heredity. The genes which are the unit factors of inheritance are discrete particles situated within the chromosomes. Each characteristic of an organism owes its presence to a particular gene or group of genes and it is not the characteristic which is inherited but the gene which produces the characteristic. Under normal conditions genes are handed on from parent to child unchanged.

Genes exist in homologous pairs or allelomorphs dealing with alternating or opposing characteristics. If each parent hands on to the child the same member of the allelomorphic pair the child will have a double dose (homozygous) of that particular gene. If, however, each parent hands on opposing allelomorphic genes the child will carry two unlike though homologous genes (heterozygous). The presence of one of these (the recessive gene) will be masked by the dominant gene and the child will bear outwardly the characteristic caused by the dominant gene only. In the case of human eye diseases, most of which are caused by recessive genes, if such recessive genes occur side by side with the dominant gene, the person will not be liable to the disease. If, however, each parent hands on to the child the recessive gene, the offspring will have a double dose of the recessive gene and will have the disease. Consanguineous marriages are not harmful in themselves but only because they make it possible for a double dose of disease-carrying recessive genes to be brought together in the children.

Dr. Pearson went on to show how the genes retain their individuality through succeeding generations and demonstrated the effects of different combinations of genes.

He then dealt with sex-linked inheritance. Many important eye diseases are sex-linked.

Dr. Hamilton followed and pointed out that hereditary defects of the eye fall into two categories, those causing blindness, and those causing sub-normal vision. One hundred and sixty pedigrees of inherited eye disease in Tasmania have been worked out by Hamilton, and these account for 19 of the known 46 inherited eye diseases. According to the researches of Counsell and Hamilton, 40 per cent of the blindness in Tasmania is due to inherited defects, namely, cataracts, Leber's optic atrophy, retinitis pigmentosa, detachment of the retina, glaucoma, and nystagmus. Those producing defective eyesight, without blindness are: microphthalmos, heratoconus, strabismus, senile macula degeneration, myopia, and astigmatism, so it is obvious that unless the problem of eugenics is faced by the Government, and the people of Tasmania, the cause of inherited eye defects and of blindness will be steadily maintained in this island. In the course of his lecture Dr. Hamilton illustrated his point by showing pedigrees of families carrying hereditary eye defects. These pedigrees were afterwards discussed by Dr. Pearson who explained their genetic significance. In conclusion Dr. Hamilton stated that a Sight Saving School had been opened in Hobart to deal with the education of children with defective sight, but the problem must sooner or later be attacked at its origin. A voluntary pre-marital advice clinic is urgently needed and voluntary sterilisation with safeguards should be made legal.

23RD OCTOBER, 1939

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

The second Clive Lord Memorial Lecture was delivered by Professor J. B. Cleland, M.D., of the University of Adelaide. Before the lecture His Excellency the Governor presented the Clive Lord Memorial Medal to Professor Cleland.

Professor Cleland gave a lecture entitled 'Some Aspects of the Ecology of the Aboriginal Inhabitants of Tasmania and Southern Australia'. (See this volume, p. 1.)

26TH OCTOBER, 1939

A special meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

Professor J. B. Cleland gave a lecture entitled 'Anthropological Expeditions in Central Australia' which was illustrated by cinema films.

13TH NOVEMBER, 1939

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

The following papers were laid on the table and taken as read:—

T. Kobayashi: 'Lower Ordovician Fossils from Junee' (printed in full in the present volume, p. 61).

T. Kobayashi: 'Lower Ordovician Fossils from Caroline Creek' (printed in full in the present volume, p. 67).

A. N. Lewis: 'Geology of the Tyenna Valley' (printed in full in the present volume, p. 33).

A. N. Lewis: 'Record of *Glossopteris* from Cygnet' (printed in full in the present volume, p. 95).

J. Pearson: 'Notes on the Blood system of the Marsupialia' (printed in full in the present volume, p. 77).

V. V. Hickman: 'The Toxopidae, a new Family of Spiders' (printed in full in the present volume, p. 125).

N. J. B. Plomley: 'The Genus *Heterodoxus*' (printed in full in the present volume, p. 19).

G. B. Thompson: 'Distribution of *Heterodoxus*' (printed in full in the present volume, p. 27).

Mr. D. Martin gave an illustrated lecture on 'The Vegetation of Mount Wellington, Tasmania' (printed in full in the present volume, p. 97).

Mr. E. T. Emmett gave a short note on 'Tasmania's Oldest Road'.

Apart from tracks and rough minor roads Mr. Emmett claimed that the Hobart-New Norfolk road, which was completed in 1819, was the first road of importance to be constructed in Tasmania. It is interesting to recall that the real genesis of the road was bushranging. On 23rd October, 1814, a gang of robbers visited the home of Dennis McCarty at New Norfolk and made off with all the valuables they could carry. To recoup him his loss McCarty asked Governor Sorell, four years later, to give him a contract to build a good carriage road 16 feet wide from Hobart to New Norfolk, on consideration of being given:—2000 acres of land; 15 men on the store for 12 months at 1½ rations each; 8 bullocks and a cart; 500 gallons of rum, duty free; a tent for the men to sleep in and tools fit for the purpose. As there was some dispute as to whether the road should be from New Norfolk to New Town or New Norfolk to Hobart McCarty was recommended to undertake the whole road and leave the final terms to the judgment of the Governor in Chief.

In a letter dated 26th June, 1819, McCarty reported to Governor Sorell that the road was completed. A survey committee was appointed to inspect the road. They reported that the work had been done badly and that it would take 16 men four months to render the road passable. Governor Collins notified McCarty that the Government would complete the road, which would become a charge against his compensation.

It would appear that no final settlement of McCarty's compensation was made but McCarty received 500 acres of land at New Norfolk and 1000 acres at Dromedary. McCarty died early in 1820.

Mr. W. F. D. Butler exhibited a gold coin which recently came into his possession. This was a five Rupee gold coin of the East India Company, which was minted between the years 1822 and 1832.

Besides the English inscription 'English East India Company' it bears an inscription in Persian which interpreted reads 'Five Rupees of the Honourable East India Company'.

In 1803 Spanish dollars were stamped and circulated in Great Britain owing to the scarcity of local currency, and later on a shipment of Spanish dollars were obtained from Bengal and were made legal tender in this Colony. The Governor converted them into the well-known Holeý dollar and Dump. Such coins passed currency in the Colony for a considerable time and helped the deficiency in currency. Many local merchants issued also their own tokens, mostly copper.

A committee of the Legislative Council was appointed to inquire into and report upon the expediency of introducing the Sicca rupee and the dollar of the United States into legal circulation of Van Diemen's Land, and such committee made a report on June 17th, 1835, which recommended that the Sicca rupee be made legal tender in Van Diemen's Land but not the dollar of the United States.

In consequence the Act 6 William IV No. 5, passed by the Legislative Council on the 2nd September, 1835, recites that 'there is at present a deficiency in the quantity of British silver money in actual circulation within this Colony, and it would therefore and for other reasons be of advantage to commerce to encourage the circulation of the rupee at or about its intrinsic value which as near as can be ascertained is 2s. or rather more'. It was therefore enacted 'that the Calcutta or Sicca rupee shall be a legal tender and be payable and received and taken in payment at or for the same sum or amount of 2s. and the said coin shall be payable and received accordingly at that rate in discharge and payment of all debts and sums whatsoever'.

Mr. Butler pointed out that this Act does not define the particular coin which was to be so taken but the wording apparently related to the silver Calcutta rupee of the East India Company. A gold coin of the value of five silver rupees would almost certainly be equally acceptable in the Colony and would easily circulate, and this coin can therefore be classed as one of the coins circulating in the Colony in or after the year 1835.

Northern Branch

Annual Report, 1939

All meetings of the 1939 Session, other than the Annual Meeting and Public Lecture, were held in the lecture room at the Queen Victoria Museum and Art Gallery. The schedule of ordinary meetings of previous years was extended, an extra meeting being held in October.

22ND MAY, 1939

Annual Report and Public Lecture

The Annual Meeting for 1939 was held in the classroom, Public Library, on this date, at 7.30 p.m.

The Hon. Tasman Shields presided. The following were elected officers for 1939:—
President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Hon. Tasman Shields, Mr. W. R. Rolph, Mr. R. S. Padman, Mr. J. R. Forward, Mr. D. V. Allen, Mr. J. E. Heritage, Dr. R. A. Scott

Hon Secretary: E. O. G. Scott.

Hon. Auditor: R. S. Padman.

The statement of accounts, which showed a credit balance of £24 1s. 9d., was read and adopted.

The Annual Meeting was followed, at 8 p.m., by a public lecture, 'Colour Photography in Tasmania' by Mr. H. J. King. The lecture was given in the Main Hall, Public Library, the accommodation of which was taxed by an audience estimated to number 350. An abstract of the lecture is subjoined.

Mr. King gave a short introductory talk on colour photography, in the course of which he discussed the several methods adopted in attacking the problem, and reviewed recent developments that have made the taking of satisfactory pictures in colour a successful commercial proposition.

The speaker then presented a remarkably fine series of coloured moving-pictures prepared by himself. Subjects dealt with covered a wide field, including pictorial characteristics of the seasons; Tasmanian scenery, particularly in the Cradle Mountain Reserve; life on the seashore; trout fishing in Tasmania, and the history of the trout from the stripping of the ova, through the development of the young, to the catching of the adult fish; common insects, with special emphasis on methods of locomotion and feeding; the unfolding and withering of the One-Day Lily; cultivated flowers; wildflowers, etc.

26TH JUNE, 1939

The President, Mr. F. Smithies, presided.

The following new members were proposed:—Miss Browne, Mr. J. Dumaresq, Mr. G. Crawford, Mr. R. Hall, Mr. W. Manson.

Dr. W. P. Holman gave an illustrated lecture, 'A Short History of the Application of Rays in Medicine', of which the following is an abstract.

Dr. Holman introduced his subject by a chronological outline of the early history of irradiation in its clinical application, illustrating his observations with some interesting pictures of pioneer methods of treatment of patients. The story was then traced through the successive stages of evolution to medium therapy, and to the modern practice of deep therapy. Present-day technique and installation were considered in some detail.

The speaker emphasised the importance in the rapid development of X-ray therapy of the co-operation of workers in various fields of science. The parts played by the physicist, the electrical engineer, and the biologist were described and assessed; and a broad sketch given of the general superstructure erected by the medical radiologist. Dr. Holman illustrated his subject with numerous diagrams and lantern slides.

The lecture was followed by a discussion. Those participating included Mr. Smithies, Mr. Lovett, Mr. Phillips, Mr. Dumaresq, and the Secretary.

The Secretary exhibited the stomach-contents of a Seven-Gilled Shark caught recently at Bell Bay, River Tamar. The material included the remains of a fair-sized bird, vertebrae of several sharks, and jaws and other bones of two or three quite large fish.

17TH JULY, 1939

The President, Mr. F. Smithies, presided.

The following new members were proposed:—Dr. W. P. Holman, Mr. J. V. Tanner.

Mr. J. A. Ingles gave a lecture, 'Lightning and Other Natural Phenomena', of which the following is an abstract.

Mr. Ingles dealt particularly with investigations he had carried out while engaged on the construction of a transmission line in Canada. Lightning, he pointed out, was a problem of distinct interest to an electrical engineer, owing to the readiness with which it could cause serious damage to transmission lines, with consequent interruption to the power supply. On his arrival in Canada, he continued work on a series of experiments begun in France, which seemed to indicate that lightning occurred with greater frequency when there was an excess of negative ions in the air. The economic implications of the liability of electrical supply and the distribution systems to damage from lightning were explored in some detail.

In treating of the other natural phenomena noted in the title of his address, Mr. Ingles presented some very interesting facts regarding the setting up of vibratory movements in transmission lines by winds of quite moderate velocity.

A full and interesting discussion, in which a number of members participated, followed the address.

21ST AUGUST, 1939

Mr. A. L. Meston gave a lecture, 'Ruined Cities of Southern Rhodesia', of which the following is an abstract.

Mr. Meston gave a general account of some of the remarkable ruins of Southern Rhodesia, which he had the opportunity of inspecting during his recent trip overseas. Special attention was paid to the ruins at Inangya, Zimbabwe, and Mapungubwe.

The speaker pointed out that unfortunately many of the ruins had been rifled, and, in some instances, partly destroyed long ago, with the result that much valuable data that might have thrown further light on the problems presented by these curious relics of bygone civilisation had become irretrievably lost. With the aid of diagrams and scale-plans the general topography of the regions under discussion was examined, and the peculiar geographical features of the sites selected by the builders were made clear. Various theories of the origin of the ruined cities were reviewed, and Mr. Meston suggested the available evidence pointed to the earliest of the structures having been erected about 900 A.D. by the ancestors of the existing Bantu race.

The lecture provoked a full and interesting discussion in which Messrs. Allen, Phillips, Evershed, Smithies, Skemp, and Scott participated.

18TH SEPTEMBER, 1939

The President, Mr. F. Smithies, presided.

Mr. P. H. Bond delivered a lecture, 'Science and the Farmer,' of which the following is an abstract.

Mr. Bond began his address with a survey of farming methods and conditions, at home and abroad, at the beginning of the 19th Century. Dealing particularly with Australian conditions, he showed how a natural course of development, with increase in population, gradually led to the exploitation of small holdings, thus creating urgent problems regarding adequate production, and, in the case of stock, disabilities arising from congestion. The speaker proceeded to trace the measures evolved by the farmer and the agricultural expert in collaboration to meet the demands of the new conditions.

In illustration of this aspect of his subject, Mr. Bond cited, and discussed, a number of examples of successful research work, directed towards control of pests, increase of soil-fertility, production of disease-resisting strains of wheat, and general improvements in stock-raising and wheat-growing.

It was pointed out that nowadays a farmer must have, in addition to his agricultural knowledge, at least a passing acquaintance with the skilled trades, some idea of engineering principles, and a smattering of the major sciences. The speaker deplored the tendency of the present educational system to urbanise the country boy, who, after all, was the person most likely to be successful on the land.

The lecture was followed by a discussion, in which Messrs. Evershed, Smithies, Allen, and Dumaesq participated.

16TH OCTOBER, 1939

In the absence of the President, Mr. W. R. Rolph presided.

Mr. E. O. G. Scott gave an address, 'Modern Museum Developments', of which the following is an abstract.

Mr. Scott pointed out that the old conception of a Museum as a building in which miscellaneous specimens and curiosities were preserved in cases, and to which the public were at certain times given access was now being rapidly superseded by a more liberal and enlightened view of its functions and potentialities. The modern Museum does not content itself with a merely passive attitude, but adopts a positive policy calculated effectively to discharge a three-fold function—namely the conservation, the increase, and the diffusion of knowledge. In a general Museum these three functions should be approximately co-ordinate.

The evolution of the new conception of the Museum was traced with the aid of a series of symbolic diagrams. In concluding his remarks, the speaker touched upon some of the outstanding developments observed in Museums studied during his trip abroad last year.

At the conclusion of the talk, a selection of Museum literature was handed around, and formed the basis of an interesting discussion.

COUNCIL MEETINGS

Council Meetings were held on 26th April, 4th June, 3rd July, 8th August, 9th October, 13th November.

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PAPERS AND PROCEEDINGS
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FOR THE YEAR

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Preliminary Survey of the Vegetation near New Harbour, South-West Tasmania

By

CONSETT DAVIS, M.SC.

Lecturer in Biology, New England University College, Armidale, N.S.W.

(Communicated by the Secretary)

(Read 11th November, 1940)

PLATES I-IV

Little has been written about the plant ecology of Tasmania, even from the purely descriptive viewpoint, and the south-west parts of the island, accessible only with difficulty, have been almost entirely neglected in the matter of vegetational studies. The paucity of existing information will, it is hoped, excuse the publication of the present rather meagre details of this interesting region.

The area studied (Text fig. 1) extends from Cox's Bight and New Harbour, bays near the western end of the south coast of Tasmania, northward to the head of Bathurst Channel and its extension Melaleuca Creek, which comprise the south-eastern arm of Port Davey, the large harbour on the southern part of the West Coast. Studies were also made of the vegetation near the mouth of Bathurst Channel, on its north side (Bramble Cove, Roaring Beach, and the slopes of Mt. Berry). For comparison, other comparable districts of Tasmania (Central Plateau, Central West Coast) were cursorily examined at other times.

The details given in this paper were recorded during two short visits, in January, 1937, and February, 1938. Although no record has been taken of the appearance of the vegetation at other seasons, the months of January and February happen to be beneficial for the recording of floristics, as most plants are conspicuous at this season, nearly all being in flower.

No exact records of the climate of the New Harbour district are available, but general data indicate that the district possesses at and near sea-level a climate which would be regarded elsewhere in Australia as a high mountain climate, representing a combination of extreme cold and high rainfall, the latter being estimated to be of the order of 100 inches per annum. The prevailing cold south-westerly winds are probably effective in conditioning vegetational distribution, and the high excess of precipitation over evaporation favours the development of swamps.

Three formations occur in the district, viz., temperate rain-forest, wet sclerophyll forest, and high moor (*Gymnoschoenus sphaerocephalus* community),

of which the last-named is by far the most important as regards total area covered. Climatically and edaphically, the area presents an environment transitional between that required for sclerophyll forest and that for high moor; the inter-relationship of these formations, and of the post-climax rain forest, renders the district extremely interesting, although it makes difficult and even arbitrary any classification in terms of the climax.

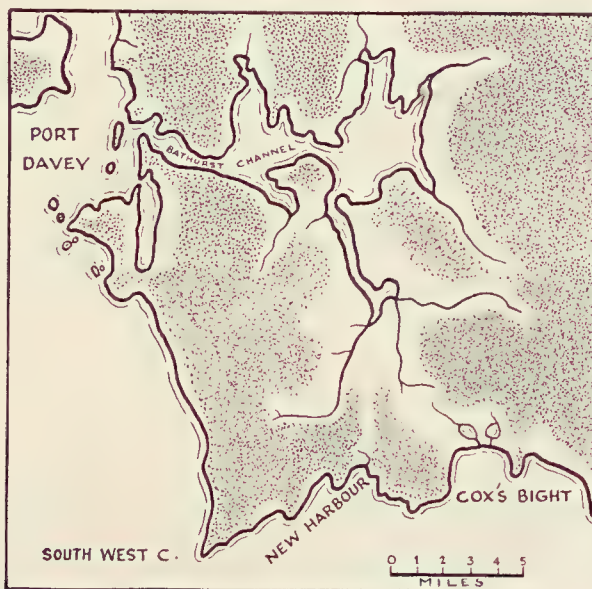


FIGURE 1.—Sketch-map of the New Harbour District. Stippling indicates approximately the distribution of high land.

THE *GYMNOSCHOENUS SPHAEROCEPHALUS* COMMUNITY

The community recognized under this name (Davis, 1941) in New South Wales, where it occurs as rather localized moors on the uplands of the South Coast, reaches its full development in Tasmania, where it is known generally by the appropriate name, 'Button-Grass Plains'. It covers a greater area in Tasmania than any other single plant community, and is particularly well developed in the New Harbour district and throughout South-West Tasmania generally.

The community covers practically the whole of the flat area between the head of Bathurst Channel on the one hand and Cox's Bight and New Harbour on the other. It also extends from the flats up the sides of the surrounding hills, until the tops or upper slopes, which are devoid of vegetation, are reached. On the western slopes (with easterly aspect), the community is much interrupted by forest. Almost the entire area investigated between Bramble Cove and Roaring Beach is also covered by the *Gymnoschoenus sphaerocephalus* community.

In facies and floristic content, the communities near New Harbour seem to be typical of those elsewhere in Tasmania, e.g., the more localized patches near Lake St. Clair on the Central Plateau (at 2500 feet approximately); in the least disturbed parts of the Queenstown district; along the Pieman River; and around Strahan, where, however, some of the expressions are rather atypical, with more shrubs. In all these cases, the community is much richer floristically than in its expressions in New South Wales.

The dominant, *Gymnoschoenus sphaerocephalus* (R.Br.) Hook.f. (Plate III, fig. 1), is a tussocky hemicryptophyte, reaching 2-4 feet in height in the New Harbour area. The community is predominantly chamaephytic, hemicryptophytic, and cryptophytic, the cryptophytes being referred to the helophyte class in view of the usually wet nature of the soil. On the upper slopes of the hills, *Gymnoschoenus* becomes less prominent in the shallower soil, and other sedges such as *Elynanthus capillaceus* tend to displace it as dominant. The shrub element is not prominent, although even in the most typical parts of the community species technically classed as nanophanerophytes are present; many of these, however, are slender and weak in growth, and in some cases are classed as nanophanerophytes although a good proportion of the specimens of the species just fail to reach the required height. In the drier parts of the community, woody shrubs increase in abundance.

The floristics of the community, as recorded at New Harbour and in the surrounding district, are as follows ⁽¹⁾:

Nanophanerophytes:

Common: *Boronia pilosa*, *Baeckea leptocaulis*, *Epacris obtusifolia*, *Sprengelia incarnata*, *Euphrasia Brownii*.

Occasional: *Casuarina distyla*, *Agastachys odorata* ⁽²⁾, *Hakea epiglottis* ⁽²⁾, *Boronia pinnata* ⁽²⁾, *Leptospermum myrtifolium* Sieb. ⁽³⁾, *Melaleuca squamea* ⁽³⁾, *M. squarrosa* ⁽³⁾, *Epacris impressa* ⁽³⁾.

Rare: *Cenarrhenes nitida* ⁽²⁾, *Lomatia polymorpha* ⁽²⁾, *Dillwynia cinerascens* ⁽²⁾, *D. ericifolia* ⁽²⁾, *Pultenaea subumbellata*.

Chamaephytes:

Common: *Drosera binata*, *Bauera rubioides* ⁽³⁾, *Azorella saxifraga*, *Utricularia dichotoma*, *U. lateriflora*, *Helichrysum pumilum*.

Occasional: *Drosera Arcturi*, *Sphaerolobium vimineum*, *Mitrasacme montana*, *Stylidium graminifolium*.

Rare: *Cassytha glabella* ⁽⁴⁾, *Pultenaea Gunnii*, *Comesperma defoliatum*, *Ampera spartioides* ⁽²⁾, *Coprosma* ? *repens*.

Hemicryptophytes:

Common: *Elynanthus capillaceus*, *Gymnoschoenus sphaerocephalus* (R.Br.) Hook.f., *Hypolaena lateriflora*, *Restio tetraphyllus*, *Xyris gracilis*.

Occasional: *Restio oligocephalus*, *Blandfordia marginata*, *Haemodorum distichophyllum*, *Campynema lineare*, *Hewardia tasmanica*, *Patersonia glauca*.

Rare: *Poa caespitosa* ⁽²⁾, *Schoenus nitens*, *Diplarrhena latifolia*, *D. moraea*.

Helophytes:

Common: *Lycopodium densum*, *Leptocarpus tenax*.

Occasional: *Lycopodium laterale*, *Cryptostylis longifolia*.

Rare: *Lycopodium diffusum* R.Br., *Prasophyllum brachystachyum*, *P. fuscum*, *P. patens*, *Pterostylis* ? *parviflora*, *Thelymitra aristata*, *T. venosa*.

In addition to these vascular plants, species of *Sphagnum* are locally common in the wetter parts of the community.

⁽¹⁾ Names used are those given by Rodway (1903) in the Tasmanian Flora. Where names not adopted in this work are used, authors' names are appended.

⁽²⁾ Drier parts of community only.

⁽³⁾ Chiefly in the neighbourhood of running water.

⁽⁴⁾ Low-growing rooted hemiparasite.

For the 59 species of vascular plants listed, the life-forms are in the proportions: N 31, Ch 25, H 25, HH 19. Omitting species not quite characteristic (chiefly shrubs, most of which are restricted to dry places), the 45 remaining species give: N 16, Ch 29, H 31, HH 24. Even this does not adequately represent the facies and life-form characteristics of the community, as the nanophanerophytes are nearly all tending towards the chamaephyte class, and the cryptophytic species are mostly rare.

Properties of a few soil samples from this community are given in Table 1 ⁽³⁾. Factors influencing the distribution of this community, and in particular those inhibiting forest development, are discussed in a later section.

SCLEROPHYLL FOREST, PSAMMOSERES, AND SHRUB SUBCLIMAX

The sample of Eucalyptus forest (wet sclerophyll forest) studied most fully was that behind New Harbour beach. This is interpreted as the culmination of a psammosere, the stages of which are accordingly first dealt with.

FESTUCA LITORALIS STAGE: Beyond the limit of wave action, the sand of New Harbour beach is clothed over a narrow zone with an almost pure stand of *Festuca litoralis*. The same species, together with *Carex pumila*, occurs in a comparable situation at Cox's Bight. In both places, plants of *Scirpus nodosus* occur occasionally in this zone, while *Poa caespitosa* occurs rather rarely at New Harbour. All these may be classed as hemicryptophytes. Soil properties for a sample from this community are listed in Table 1.

This stage is scarcely represented at Roaring Beach, where the dune, beyond the limit of wave action, rises steeply, and is covered with shrubs. This is a common configuration on West Tasmanian beaches, e.g., near the mouth of the Henty River. The few situations at Roaring Beach where vegetation is developed at a level lower than the shrubs carry the chamaephyte *Mesembryanthemum acquilaterale*, or occasionally, in small sand accumulations, the following species:

Chamaephytes: *Scirpus cartilagineus* (incl. var. *propinquus*), *Salicornia australis*, *Plantago Brownii*, *Cotula filicula*.

Hemicryptophytes: *Schoenus nitens*, *Oxalis corniculata*.

SHRUB DUNE: At New Harbour, the community noted above passes into a zone containing rather widely scattered shrubs, the following being the floristic composition:

Nanophanerophytes:

Common: *Leucopogon Richei*, *Ozothamnus cinereus*.

Occasional: *Correa Laurenciana*.

Rare: *Hakea epiglottis*, *Persoonia juniperina*, *Leptospermum lanigerum*, *Ozothamnus scutellifolius*, *Senecio dryadeus* Sieb., *S. laetus*.

Chamaephytes:

Common: *Acaena sanguisorbae*.

Occasional: *Colobanthus Billardieri*, *Epilobium confertifolium* H., *E. junceum*, *Mentha serpyllifolia*.

Rare: *Ampera spartioides*, *Stackhousia linariifolia*, *Helichrysum apiculatum*.

Therophytes:

Common: *Helichrysum scorpioides*.

Rare: *Leontodon hirtus* L. (introd.).

⁽³⁾ For methods used in the estimation of soil properties see Davis, 1941. Of the loss on ignition figures listed in Table 1 for this and other communities, over 50 per cent, sometimes nearly 100 per cent, represents humus, as indicated by the hydrogen peroxide method.

In addition to these, species of the preceding stage occasionally occur. Properties of a sample of the soil of this community are given in Table 1.

At Roaring Beach, a dense growth of shrubs is developed on the steep dune behind the beach, but, since it has neither the pioneer community developed in front, nor forest (climax?) behind, it is difficult to regard it as a seral stage. In most places, it passes on the landward side into the *Gymnoschoenus sphaerocephalus* community. The floristic composition is listed as an indication of the potential species of the shrub stage of a psammose, as the similar conditions at New Harbour for some reason fail to give rise to such a variety of shrubs:

Nanophanerophytes:

Common: *Banksia marginata*, *Persoonia Gunnii*, *Acacia verticillata* var. *latifolia*, *Correa Laurenciana*, *Leucopogon Richei*, *Westringia rigida*, *Ozothamnus cinereus*.

Occasional: *Exocarpus stricta*, *Leptospermum myrtifolium* Sieb., *Cyathodes acerrosa*, *Olearia stellulata* DC.

Rare: *Persoonia juniperina*, *Bedfordia salicina*.

Geophytes:

Occasional: *Lepidosperma gladiata*.

Rare: *Pteridium aquilinum* (L.) Kuhn.

Some of the larger of the shrubs actually pass into the microphanerophyte class.

SCLEROPHYLL FOREST: At Roaring Beach, and in most places on the foreshores of Cox's Bight, the communities behind the beach pass into the *Gymnoschoenus sphaerocephalus* community without any development of forest. At New Harbour, however, Eucalyptus forest (wet sclerophyll forest) is well developed on former beach sand, in the zone behind the communities listed above. (See Plates I, II, and IV, fig. 2.) The trees reach about fifty feet in height, with closed canopy; low trees (and tall shrubs) form a discontinuous but quite marked layer. The lower shrub and ground strata are seldom continuous, but, with fallen timber, are dense enough to impede passage on foot.

Soil properties for this community are listed in Table 1. The following species are recorded:

Mega- and mesophanerophytes:

Common: *Eucalyptus ovata*, *E. (?) Sieberiana*.

Rare: *Phyllocladus rhomboidalis*.

Microphanerophytes:

Common: *Banksia marginata*, *Drimys lanceolata* Baill.

Occasional: *Cenarrhenes nitida*, *Pomaderris apetala*.

Nanophanerophytes:

Common: *Cyathodes acerrosa*, *Zieria macrophylla* Bonpl.

Occasional: *Persoonia Gunnii*, *Correa Laurenciana*, *Pimelea drupacea*.

Nanophanerophyte (climber):

Occasional: *Billardiera longiflora*.

Chamaephytes:

Common: *Dianella revoluta*.

Occasional: *Urtica incisa*, *Stackhousia linariifolia*, *Brachycome* sp.

Therophytes:

Occasional: *Helichrysum scorpioides*.

Rare: *Galium australe*.

This community extends to a depth of only a few hundred yards, giving place on the inner side to the *Gymnoschoenus sphaerocephalus* community. In aerial views of this part of the latter community, lines running as arcs of circles more or less concentric to that of the beach and present sea limit are clearly visible. If these are interpreted as former strand-lines, we must assume that they have at some time carried Eucalyptus forest, which has been displaced by the moor community, the forest maintaining itself only near the beach, where drainage through the porous sand, unimpeded by humus, is more efficient, and where the lateral course of the water draining through the soil is in any case shorter. The apparent ease with which moor is thus able to replace forest must be borne in mind in considerations as to which formation is the natural climax of the region.

Eucalyptus forest is also developed in many other places in addition to that behind New Harbour Beach. On the drier slopes surmounting the moors behind Cox's Bight and New Harbour, and especially those with easterly aspect, forest similar to that behind New Harbour beach occurs. It also occurs on some of the small hillocks within the *Gymnoschoenus sphaerocephalus* community; the species on one such local rise, on the plain north of New Harbour, proved to agree fairly closely with the hind-dune forest, the following additional species being recorded as fairly common: Chamaephyte, *Halorrhagis teucrioides*; hemicryptophytes, *Lomaria discolor*, *L. procera*; geophytes, *Histiopteris incisa* (Thunb.) J.Sm., *Pteris tremula*. The occurrence of certain trees in this clump, e.g., *Anopterus glandulosus*, suggests that it tends towards temperate rain forest; the situation, on the west side of the plain, is somewhat sheltered from the west. Properties of a soil sample from this clump of trees are given in Table 1.

TABLE 1

Soil.	Water- retaining Capacity. Per cent.	Loss on Ignition. Per cent.	pH.	Chloride. Per cent.
Sand Dune	59.	3.4, 3.6	7.4	.01
Shrub Dune	71.	14, 20	7.0	.04
Dune Forest	200.	58, 64	5.7	.32
Eucalyptus Forest (clump in middle of swamp)	220.	47, 48	6.1	
<i>Gymnoschoenus sphaerocephalus</i> Com- munity	{ 108. 121.	{ 33. 46.	{ 4.8 4.3	{

On some of the ridges behind Cox's Bight, different species of Eucalyptus (*E. amygdalina*, *E. linearis*) are dominant. No explanation for this difference can be suggested.

SHRUB SUBCLIMAX: On the cliffs around New Harbour, especially those on the east side, the soil is too shallow and unstable for tree development, but is well-drained, so that shrubs are developed rather than the *Gymnoschoenus sphaerocephalus* community. The same type of vegetation occurs on some of the islands in the district, e.g., Breaksea Island in the mouth of Port Davey. As conditions of erosion indicate that these shrub communities have little prospect of proceeding by succession to forest, they are regarded as subclimax vegetation rather than as a stage of a lithosere.

The following species occur in the shrub community at New Harbour:

Nanophanerophytes:

Common: *Banksia marginata*, *Leptospermum myrtifolium* Sieb.

Occasional: *Persoonia Gunnii*, *Drimys lanceolata* Baill., *Acacia verticillata* var. *latifolia*, *Correa Laurenciana*, *Cyathodes acerrosa*, *Leucopogon collinus*.

Hemicryptophyte:

Common: *Blechnum cartilagineum*.

Geophyte:

Common: *Pteridium aquilinum* (L.) Kuhn.

TEMPERATE RAIN FOREST

This formation is, in Tasmania, dominated characteristically by *Nothofagus Cunninghamii* (Hook) Oerst., which may be displaced locally by other lower trees, e.g., *Eucryphia Billardieri*, *Anopterus glandulosus*, *Anodopetalum biglandulosum*. These give the vegetation an entirely different facies, but the areas (e.g., those dominated by *Anodopetalum*, the 'Horizontal Scrub') may still be regarded as belonging to the formation.

In its characteristic form, dominated by *Nothofagus*, the formation in the New Harbour district seldom reaches within several hundred feet of sea-level, as it does on the Central West Coast (King River). This is probably due merely to the lack of suitably sheltered areas at low levels. In the sheltered gullies in hills north-west of New Harbour (easterly aspect), pockets of the community, which may be called the *Nothofagus Cunninghamii* association, are developed, apparently typical of the association as expressed elsewhere in Tasmania. The dominant, a tall tree, has a closed canopy; low trees (e.g., *Anopterus glandulosus*, *Drimys lanceolata* Baill.) are present rather sparsely; the ground flora is composed chiefly of ferns (e.g., *Lomaria procera*), and is discontinuous. Small vascular epiphytes (e.g., *Hymenophyllum flabellatum*) are common, as well as bryophytes. The interesting epacrids, *Richea scoparia* and *Dracophyllum Milligani* Hk., occur occasionally.

Along some creeks, e.g., in the *Gymnoschoenus sphaerocephalus* community, where there is insufficient shelter for *Nothofagus* to develop, some of the elements of the formation occur as low trees (e.g., *Anodopetalum*, *Anopterus*). In the sheltered part of a small gully at the south end of Roaring Beach, *Anopterus* dominates a small community which may be regarded as low-grade rain-forest. In these situations, units of the other formations, e.g., *Epacris impressa*, *Cyathodes acerrosa*, are often present.

DISCUSSION

The variables which, as units of the total environment, govern the vegetational pattern in the New Harbour district may be subdivided as follows, gross climate (as opposed to microclimate) being taken as a constant:

Topography: The contour of (a) land surface and (b) bedrock surface (never of course coinciding where vascular vegetation is present) are primary factors in vegetational distribution. The former is important in respect to shelter, and temperate rain-forest is restricted to locations sheltered from the prevailing south-west winds. Land form is also important with respect to drainage, hillocks and ridges, with water-table lower than flat or undulating land, being necessary for forest development in such a wet climate, except where the soil is deep and permeable (e.g., in some rain-forest gullies and in the forest of the psammosere at New Harbour beach). The contour of bedrock is chiefly important in its effect on

drainage, although, in so far as it represents the depth of the soil, it is effective in limiting forest development, e.g., in the shrub subclimax of the shallow soils of the cliffs near New Harbour.

Most of the soils of the plains behind New Harbour and Cox's Bight are relatively shallow, six feet being judged an average from inspection of the various tin workings, and the surface of the underlying impermeable quartzite rock is fairly level. These conditions are conducive of a high water-table. Immediately beside many of the creeks, however, the water-table is lower and small trees of *Eucalyptus* spp., and shrubs, are present (Plate I). This apparent paradox is explained by Text fig. 2; the creeks have steep or vertical banks, and the water has cut through to the underlying rock; the banks are therefore better drained in all cases than those parts of the *Gymnoschoenus sphaerocephalus* community away from creeks. It should not be overlooked, however, that some few shrubs (e.g., *Leptospermum myrtifolium* Sieb., *Melaleuca squamea*) are able to grow in the wettest situations.



FIGURE 2.—Diagrammatic section across a creek in the *Gymnoschoenus sphaerocephalus* community, plain north of New Harbour. Horizontal scale 1 inch = 10 yards; V/H = 3/1. Black, quartzite rock; heavy stippling, water-logged soil; light stippling, soil not water-logged; broken line, water table.

A, *Gymnoschoenus sphaerocephalus*; B, shrubs; C, low trees; D, straggling plants such as *Bauera rubioides*, *Epacris impressa*, &c.

It has been noted that, while temperate rain-forest is confined to positions of easterly aspect, even *Eucalyptus* forest seems to prefer the western (east-facing) hills, though occasionally forming on west-facing slopes (e.g., immediately north-east of New Harbour). This may mean that the development even of trees of *Eucalyptus* is inhibited in part by the prevailing winds, but another (perhaps supplementary) explanation can be offered. The dip of most of the strata, which consist of much-altered sedimentary rocks, is to the east, and on the westerly-facing slopes the weathered ends of successive strata tend to impede water flow, and favour the development of moor instead of forest; on the east-facing slopes, the contour of rock surface is parallel, more or less, to the bedding planes, and drainage is facilitated.

Rock Type: This aspect of the investigation received too little attention, but a few preliminary notes may be put on record. In the first place, humus development and accumulation are so favoured by the climate that the texture of the original soil (i.e., as derived from rock decomposition, without the modification caused by humus) is less important than in some climates (cf., e.g., Davis 1941, with regard to the Bulli district, New South Wales, where humus content is generally low, and only in special situations is able to counteract the coarseness of texture of some soils in its effect on water-retaining capacity). The very high water-retaining capacity of the dune forest soil (200 per cent) may be cited as a

case in point, as dune sand less humus is one of the poorest of water-retainers ⁽⁶⁾. Here, the very coarseness and porosity of the dune soil seems to favour, rather than retard, the presence of a higher type of vegetation (sclerophyll forest as opposed to moor), if the swamp behind the dune forest has been correctly interpreted as a corollary to the progress of the psammosere.

In spite of the fact that the high average humus content rather discounts the effect of the soil texture as derived from the parent rock, it seems that forest, and especially rain-forest, is favoured by slate areas rather than the prevailing quartzite and granite in this district. This may perhaps be explained by the greater ease of weathering of the slate, and therefore the deeper soil of these areas, where the more deeply underlying bedrock has less effect in retarding drainage.

Any attempt to classify the vegetation in terms of the climax, under the concept that this is primarily controlled by climate, must be arbitrary in a zone transitional in climate between two types characterized by two recognized climax formations. Two schemes can be suggested: (1) Sclerophyll forest is the climax, moor is a subclimax due to physiographically-controlled high water table, and rain-forest postclimax. (2) Moor is the climax, sclerophyll and rain-forest primary and secondary postclimaxes. Actually, the region seems to be intermediate between that with moor as the climax formation, and that with sclerophyll forest. If any definite scheme is to be adopted, the second of those above seems preferable, as the moor formation is the most important spatially, and also since forest apparently passes into moor at the close of the psammosere.

The life-form spectrum of the moor formation is suggestive of a swamp community in any climatic zone, the life-forms which predominate giving little direct indication of the climate, but rather being characteristic of the soil conditions. Fires are frequent in the *Gymnoschoenus sphaerocephalus* community in the New Harbour district, spreading spontaneously when started even in damp and misty weather; if the hemicryptophytic and helophytic life-forms have any significance, it is probably in their survival value in the event of burning.

My thanks are due to Dr. F. Rodway, of Nowra, for identifying many of the specimens collected, and to Mr. S. Fowler, of the C.S.I.R. (Fisheries Division), for permission to use aerial photographs taken by him.

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⁽⁶⁾ It should be noted, nevertheless, that the sand at New Harbour is of finer texture than that usually encountered in New South Wales; its W.R.C. is 59 per cent, as opposed to 30 per cent as an average for soils of this stage in New South Wales with corresponding loss on ignition.

PLATE I

Oblique aerial photograph of New Harbour, looking south-west. Psammosere behind beach; Eucalyptus forest (other than that of psammosere) on ridges east of New Harbour Creek, and on parts of the cliffs of New Harbour; shrub communities on cliffs east of New Harbour. Elsewhere, the *Gymnoschoenus sphaerocephalus* community is present, except on weathered hill-tops devoid of vegetation. The tendency for tree devolepment along the banks of New Harbour Creek, well back from the dune zone, is also visible.



PLATE II

1. Vertical view of north-east corner of New Harbour, north side to the top. Vegetation comprises psammosere (behind beach), and *Gymnoschoenus sphaerocephalus* community, except where bare rock is exposed (hill-tops), or where better drainage permits shrub development on the cliffs on the right (east) side.
2. Oblique aerial view of New Harbour, direction of view south of east; Cox's Bight in the background. Psammosere behind beach; *Gymnoschoenus sphaerocephalus* community rising to bare rock on hill-tops; and shrub communities on shallow well-drained soil on cliffs immediately above the sea, east of New Harbour.

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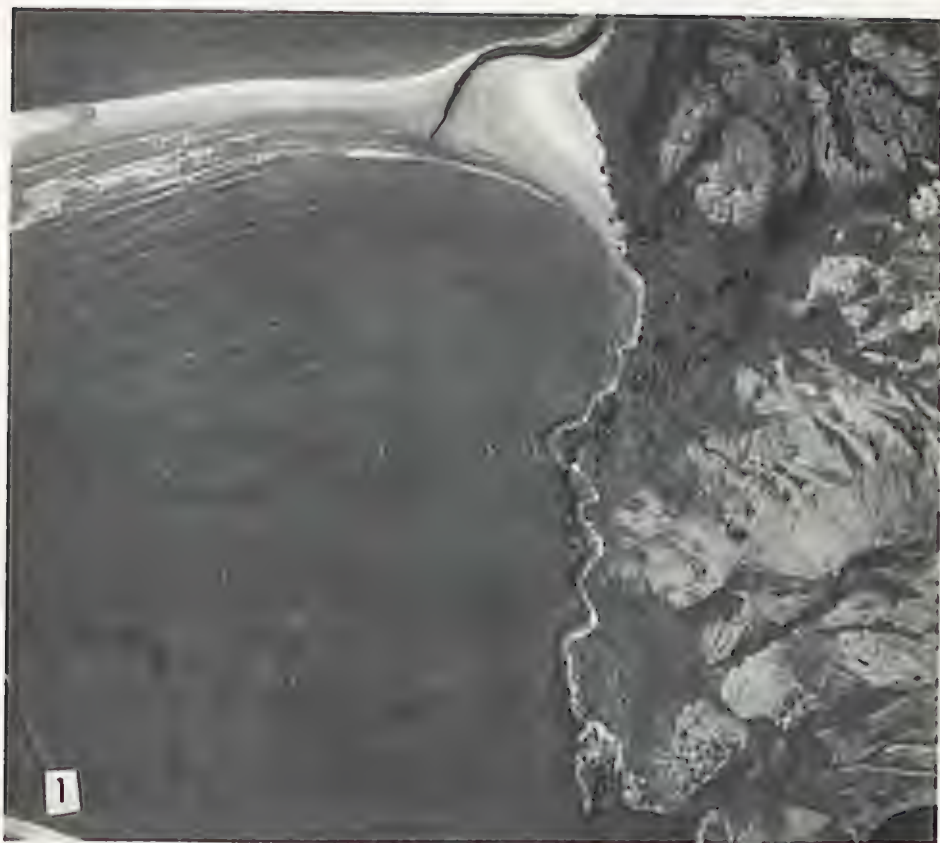


PLATE III

1. *Gymnoschoenus sphaerocephalus* community, near Cox's Bight.
2. Looking south-east towards Cox's Bight, from hills between Cox's Bight and New Harbour. The entire plain is covered by the *Gymnoschoenus sphaerocephalus* community, which extends up the surrounding hills until the bare rock zone is reached.
3. Ridges behind and to the east of the beach, New Harbour, with *Gymnoschoenus sphaerocephalus* community, and Eucalyptus forest in positions of better drainage.



PLATE IV

1. Hills behind and to the west of Cox's Bight, with easterly aspect. *Gymnoschoenus sphaerocephalus* community, with a pocket of temperate rain-forest in a well-drained gully sheltered from the west.
2. Psammosere, New Harbour beach, looking north-east: *Festuca litoralis*, shrub dune, and dune forest. The hills in the background are partially covered with the *Gymnoschoenus sphaerocephalus* community.
3. Roaring Beach, Port Davey: Shrubs developed on steep slope of blown sand behind the beach; elsewhere, the high water-table limits the vegetation to *Gymnoschoenus sphaerocephalus* community.
4. Cliffs in the New Harbour district, with shrub subclimax developed on well-drained but shallow and shifting soil.



The Lower Tertiary (Miocene) Marine Sedimentary Rocks of the Far North-Western Districts of Tasmania

By

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(Read 11th November, 1940)

The main objectives of this paper are to bring together all references to Tertiary marine rocks; to publish together the various lists of fossils determined from time to time and some of which have not been published; to publish a list of fossils from Marrawah as determined by Mr. F. Chapman in 1932-1933 (see Appendix), and to determine the age of the rocks in accordance with the palaeontological evidence. The age of the rocks is important because that of other rocks (e.g., basalt) in the same region is dependent upon the age of the Tertiary marine rocks.

The far north-western districts are those to the west of a line joining Montagu and Balfour, and they represent the extreme north-western portion of the State (see map).

The generic and specific names of fossils are those given in the original descriptions of the palaeontologist who examined the specimens.

REVIEW OF THE LITERATURE

The rocks now referred to as Tertiary marine rocks were discovered by P. E. de Strzelecki who carried out scientific exploratory trips in New South Wales and Van Diemen's Land in 1841 and 1842. Strzelecki, however, referred to these rocks as 'elevated beaches', and reported their occurrence at Green Is., south-west point of Flinders Is., Table Cape, and ten miles south of Cape Grim. His description of the latter locality is: 'At ten miles south of Cape Grim and west coast of Van Diemen's Land are found, at 100 feet above the present sea, elevated beaches, similar to those of Bass's Straits, and approaching in structure to a coarse and porous sandstone'. No fossils were recorded (Strzelecki, 1845).

R. C. Gunn (1855) referred to raised beaches on certain parts of the north-west coast, but those referred to are of Recent and not of Tertiary age.

The Table Cape beds became the best known of the deposits discovered by Strzelecki as, according to Stephens (1870) several collections of fossils had already been donated to the Tasmanian Museum. Stephens' paper was written

to illustrate the geology of the North Coast, on the occasion of the presentation of a larger collection of fossils by Mr. Hainsworth. Stephens in this paper referred to the Table Cape beds as Tertiary marine beds, and was apparently the first to do so.

Johnston (1879) described certain Tertiary and Post-Tertiary beds on Flinders and other islands in the eastern part of Bass Strait, and also made brief mention of those at Table Cape, 10 miles south of Cape Grim, and Hunter's Island. Johnston stated that the 'elevated beaches' of previous writers had been shown by recent investigations to be 'remains of the floor of a vast but shallow sea of supposed miocene or oligocene age' In this he followed the expressed opinion of Tenison-Woods (1877).

During 1875 and succeeding years, Tenison-Woods, Johnston, and others described fossils from the Table Cape beds, but the rocks and fossils from the Table Cape locality will not be further considered in this paper.

Johnston (1888) refers to Strzelecki's discovery of 'elevated beaches' 10 miles south of Cape Grim, and states that, while he had not visited the beds, samples of polyzoal limestone had been sent to him by Messrs. Emmett and J. Norton-Smith, who described the cliffs south of Cape Grim as consisting mainly of horizontally bedded polyzoal limestone capped by basalt. Mr. Smith also reported that the limestones appeared to the east in the valley of the Welcome River. Johnston recognized the following fossils:—

Polyzoa	<i>Cellepora gambierensis</i> (Busk)
	———— <i>spongiosa</i> (Busk)
	———— <i>nummularia</i> (Busk)
	———— <i>hemispherica</i> (Busk)
	<i>Lepralia</i>
	<i>Eschara</i>
Corals	<i>Placotrochus deltoideus</i> (Duncan)
Echinodermata	<i>Lovenia Forbesi</i> (Woods and Duncan)
Brachiopoda	<i>Waldheimia grandis</i> (T. Woods)

Twelvetrees (1908) referred to the polyzoal limestone near Cape Grim and the Welcome R., but the descriptions are based upon those of Johnston (1888).

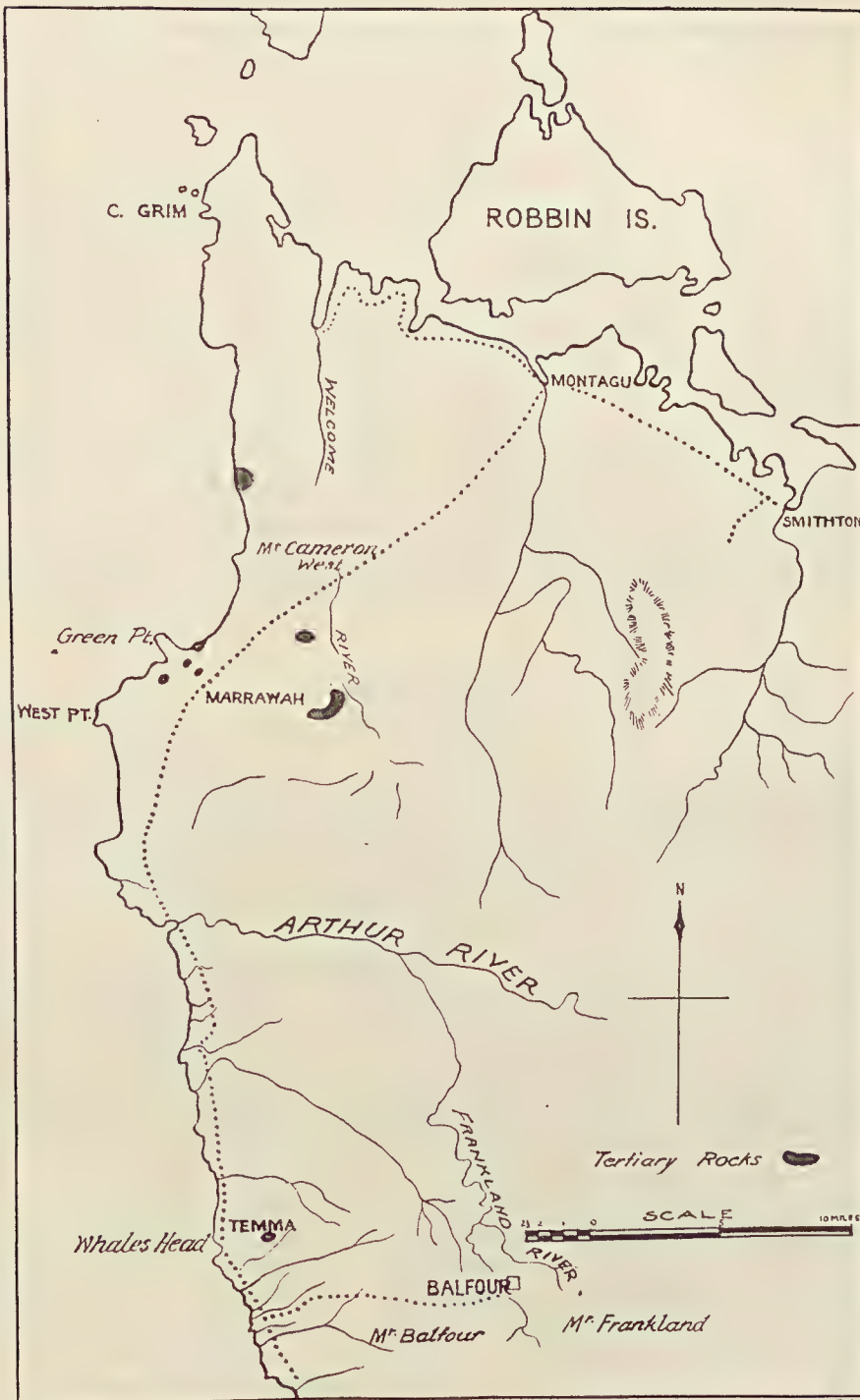
During the course of the geological survey of the Mt. Balfour Mining Field, L. K. Ward (1910) discovered Tertiary limestones near Temma and also near Marrawah, the exact localities being—

- (1) In the north-western corner of a 99-acre block charted in the name of Louis Hogg. At height of 250 feet above sea level.
- (2) A. Wilson's farm east of Marrawah (Note . . . probably north to north-west of Redpa). At height of 150 feet above sea level.
- (3) On beach close to Marrawah, south of Mt. Cameron west and east of Green Point. Between high and low tide.
- (4) As pebbles on beach between Ordnance Point and Daisy Creek.

The fossils obtained by Ward in 1910 were submitted to W. S. Dun, Government Palaeontologist of New South Wales, who made the following determinations:—

Locality (2) above

Polyzoa: *Retepora*, *Cellepora*, *Lepralia*, *Microporella*, *Schizoporella* (?)
 Brachiopoda: *Terebratula garibaldiana*.



Locality (1) above

Polyzoa: Most of the polyzoa quoted above.

Brachiopoda: A terebratulid which resembles *T. garibaldiana*.

Gasteropoda: *Marginella*, *Calliostoma*.

Mr. Dun added that 'There is in my opinion every reason to correlate these beds with the Table Cape beds and Cape Grim beds.'

In 1916, Mr. H. T. Lawson submitted some fossils from a limestone quarry at Marrawah (the quarry being about 6 or 7 miles from the coast) to the Geological Survey. The specimens were submitted to Mr. F. Chapman who determined the following fossils (Twelvetrees, 1917):

Pleurotomaria sp. (cast) with annectant characters between *P. tertiara*, McCoy, and *P. bassiana*, Pritchard.

Cypraea sp. (cast) resembling *C. subsidua*, Tate, or *C. leptorhyncha*.

Conus cf. *complicatus*, Tate, and added—

'The relationships of this small collection points unmistakably to the Janjukian (Table Cape) series. The condition of the fossil casts resembles that of the limestones of the Moorabool Valley near Maude, Victoria.'

The friable calcareous sandstones referred to by Meston (1933) in his recent paper on aboriginal carvings on the coast, 10 miles south of Cape Grim are close to Strzelecki's locality and undoubtedly belong to the marine beds of Tertiary age.

OTHER LOCALITIES

During 1932, the writer discovered other localities in the Marrawah district, viz.:—

(1) On the western side of the Welcome River plain, 3 miles south-south-east of Redpa. The rock is a hard, pink limestone, horizontally bedded and unconformably overlying steeply dipping beds of Cambro-Ordovician limestone and dolomite. The limestones are fairly extensive and at least 100 feet thick and appear to fringe the basalt hills. The base of the limestone beds is 135 feet above sea-level.

(2) On the eastern portion of G. Loverock's property, one mile west of Marrawah. The rock is white polyzoal limestone. There is no definite outcrop, loose pieces being present in the soil. The extent does not appear to be large and the occurrence is 250 feet above the sea.

(3) On the opposite side of the road to Mr. J. N. Nicholls' house 1½ miles west of Marrawah. Two small quarries in this locality expose a white, polyzoal limestone. The beds are 190 feet above the sea. They cannot be traced beyond the quarries, and the extent does not appear to be large.

(4) Near the south-western portion of J. N. Nicholls' property and on the adjacent property to the south. Several exposures exist in this vicinity at heights ranging from 200 to 250 feet above the sea. The lowest is an excavation at the site of a former spring and reveals a stream of water issuing from a solution channel in white limestone. At a higher level, a small quarry exposes a similar limestone, from which Mr. Nicholls' collection was obtained. On Saward's land block several shafts have been sunk in attempting to obtain a water supply. The material on the dump of the last to be sunk consists of white weathered limestone and brownish mudstones.

The fossils obtained by the writer, together with a private collection loaned by Mr. J. N. Nicholls of Marrawah, were submitted to Mr. F. Chapman, Commonwealth Palaeontologist, in 1932, whose determinations and report are given in the appendix at the end of this report. Mr. Chapman's conclusions were that the age of the limestone was Lower Miocene.

CONCLUSIONS

Tertiary marine sedimentary rocks have been discovered at numerous places on the north and west coasts of the far north-western districts of the State. While the outcrops are not connected with one another, they represent in some districts the remnants of beds that were once more extensive, and indicate considerable transgressions of the Tertiary sea in such districts. The beds were probably most extensive in the Marrawah - Cape Grim - Welcome River district, though they have since been largely removed by erosion and probably also covered by later sand deposits. The greatest transgression of the sea probably occurred in this district, and extended inland to a distance of at least $7\frac{1}{2}$ miles from the west coast. The rocks consist mainly of polyzoal limestones, with subordinate amounts of calcareous sandstones and brownish mudstones.

The determinations of fossils from Temma, Marrawah, and Cape Grim prove the rocks to be of Lower Tertiary age, and that they can be correlated with the Table Cape beds further to the east. The latest determination (by Mr. F. Chapman) indicates a Lower Miocene age.

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Appendix

Report on a Collection of Fossils from Marrawah, Smithton

(Received from the Tasmanian Mines Department on 20th December, 1932)

By F. CHAPMAN, F.L.S., Commonwealth Palaeontologist

Marrawah, Tasmania	(Private Collection)
Polyzoa	<i>Cellepora coronopus</i> Busk
	<i>Cellepora biradiata</i> Waters
	<i>Schizellozoon</i> sp.
Echinoderma	<i>Linthia</i> sp.
Brachiopoda	<i>Magellania grandis</i> (T. Woods)
	<i>Magellania garibaldiana</i> Dav.
Pelecypoda	<i>Chlamys praecursor</i> (Chapman)
	<i>Chlamys</i> cf. <i>praecursor</i> (Chapman)
	<i>Ostrea</i> cf. <i>Hyotidoidea</i> Tate
	<i>Cypraea</i> cf. <i>leptorhyncha</i> McCoy
Pisces	<i>Isurus retroflexus</i> Ag.

The age of these fossils is Lower Miocene.

Marrawah, Tasmania .. (Geol. Surv. Coll.)

Pink limestone, 3 miles S.E. of Redpa:—

Hard, pink polyzoal limestone. In this section, it consists almost entirely of polyzoal fragments set in a calcitic matrix. A few foraminifera are present, including *Textularia gibbosa*, *Quinqueloculina* sp., and numerous small rotalines; also echinoid plates and spines.

The age of the rock is Lower Miocene. It compares closely with the pink limestone from Mt. Gambier, South Australia, which is also Lower Miocene.

Limestones, 1½ miles S.S.E. of Green Point, Marrawah:

(a) Weathered, yellowish, polyzoal limestone (with foraminifera (*Carpentaria rotaliformis*), polyzoa (*Cellepora fossa*) and cidaroid plates.

(b) Whitish, marly, polyzoal limestone. Washings contain foraminifera, polyzoa and brachiopoda.

Foraminifera:—

Textularia carinata d'Orb.*Textularia sagittula* Defr.*Lenticulina orbicularis* d'Orb.*Globigerina bulloides* d'Orb.*Globigerina triloba* Ruess.*Globigerina* cf. *inflata* d'Orb.*Carpentaria alternata* Chapm. & Crespin.*Carpentaria rotaliformis* Chapm. & Crespin.*Anomalina nonionoides* Parr*Discorbis turbo* D'Orb.*Heronallenia lingulata* (Burr. & Holl.)*Cibicides refulgens* (Montf.)*Cibicides ungerianus* (d'Orb.)*Cibicides culter* (P. & J.)

- Siphonina australis* (Cushman)
? *Spirillina decorata* Brady
Eponides scabriculus (Chapman)
Eponides karsteni (Reuss)
Elphidium antonina (d'Orb)
Planorbulinella larvata (P. & J.) var. *plana* H. & E.

Anthozoa:—

- Mopsea tenisoni* Chapman
Mopsea sp. nov.

Polyzoa:—

- Cellaria australis* McG.
Schizolavella phymatopora (McG.)
Acropora gracilis (M. Edws.)
Hornera striata M. Edws.
Idmonea trigona McG.
Idmonea incurva McG.
Lichenopora sp.

Brachiopoda:—

- Murravia triangularis*

The age of these two limestones is Lower Miocene.

On a Remnant of a Stripped Peneplain of Palaeozoic Age at Mount Sedgwick in Western Tasmania

By

A. B. EDWARDS, PH.D., D.I.C.

(Read 11th November, 1940)

PLATE V

It is well established (Nye and Blake, 1938, pp. 22, 42) that a peneplain existed over much of Tasmania at the beginning of the Permo-Carboniferous sedimentation. Beds of Permo-Carboniferous and Trias-Jura sediments were laid down on this surface, and, apart from tilting, retain their original horizontal relations. At, or near, the close of the Trias-Jura sedimentation, the intrusion of a dolerite magma occurred on a widespread scale, forming huge dykes and sills. The sills were confined to the horizontally bedded strata, or to the plane of weakness at their base where they rested on the surface of the peneplain.

It is not known whether this peneplain extended to Western Tasmania, or whether it gave place to an irregular erosion surface in that region. The distribution of the Permo-Carboniferous rocks (see below) makes it clear that, even in the latter case, the irregularities of the erosion surface were nothing like as great as those existing to-day. This view is implicit in the opinion of Loftus Hills (1914, p. 25) that at one period 'the central plateau was practically continuous with the West Coast Range, which did not then exist as a separate mountain range'.

THE STRIPPED PENEPLAIN

At Mount Sedgwick, in the West Coast Range, there occurs a small plateau which appears to be an uncovered portion of this old peneplain. Mount Sedgwick, which is about 4000 feet high, is the highest peak of the West Coast Range in this part of Tasmania (Table I). The summit consists of a pyramidal hill of columnar dolerite, about 300 feet thick ⁽¹⁾, portion of an originally thicker and more extensive sill or laccolith. The base of this sill or laccolith is practically horizontal (Plate V, fig. 1), and it lies on a flat surface composed of quartz-felspar-porphry (Devonian age), West Coast Range Conglomerate (Silurian age),

⁽¹⁾ T. B. Moore (1894) gives the thickness of the dolerite as 800 to 1000 feet, but this is an exaggeration, and is contradicted by his further statement (p. 148) that he discovered a bed of glacial conglomerate containing coal measure (Permo-Carboniferous) fossils 'at an elevation of 3500 feet above sea-level, adjoining the greenstone on the south-east side of the mount.'

and possibly a small remnant of Permo-Carboniferous sandstone ⁽²⁾ at its north-east margin. The dolerite was, therefore, intruded practically between the base of the Permo-Carboniferous at this locality and the Palaeozoic erosion surface.

This surface continues as a small, relatively flat plateau, where it emerges from beneath the dolerite (Plate V, fig. 2). It has been scored by the Pleistocene glaciers, which carved hanging valleys in its margins (Plate V, figs. 1 and 3), and left channels now occupied by lakes. There seems little doubt, therefore, that this plateau, which forms the 'pedestal' on which the dolerite cap of Mount Sedgwick rests, is portion of a stripped peneplain, or of an erosion surface contiguous with the pre-Permo-Carboniferous peneplain that existed in other parts of Tasmania. Some conception of its extent can be obtained from the aerial view of it shown in Plate V, fig. 1. The dolerite summit of Mount Sedgwick appears on the right, and the dolerite-capped peaks of the Eldon Range show in the centre background. The photo is reproduced by the courtesy of Messrs. Nankivell, of Queenstown.

The surface of this uncovered erosion surface stands at about 3700 feet above sea level ⁽³⁾, and is not greatly lower than the present summits of the other mountains of the southern end of the West Coast Range (Table 1).

TABLE 1

<i>Mountain.</i>	<i>Height above Sea-level.</i>	<i>Source.</i>
	<i>Feet.</i>	
Sedgwick	4000	Blake
Tyndall	3875	Moore (1893)
Giekie	3950	Moore (1893)
Jukes	3790	Loftus Hills (1914)
Sorell	3730	Loftus Hills (1914)
Owen	3600	Loftus Hills (1914)
	3800	Gregory (1904)
Darwin	3340	Loftus Hills (1914)
Huxley	3200	Blake
Lyell	3050	Gregory (1904)

If its level is assumed to represent the general level of the erosion surface or peneplain in this region, then it is apparent that several of the present mountains formed monadnocks rising several hundred feet above the level of the peneplain.

POST-PALAEOZOIC FAULTING

Similar monadnocks also occurred further to the west, because granite pebbles, presumably derived from the Heemskirk massif, have been found near Zeehan in a tillite which is regarded as belonging to the basal stage of the Permo-Carboniferous (Twelvetrees and Ward, 1910, pp. 9, 42). Mount Heemskirk (2700 feet) and Mount Zeehan (2500 feet) stand considerably higher than this tillite, and presumably they stood still higher at the beginning of the Permo-Carboniferous.

⁽²⁾ Fossiliferous sandstones containing casts of *Spirifer* and *Aviculopecten* have been collected from this point by Mr. W. Morris of the Survey Staff of the Lyell Comstock Mine.

⁽³⁾ T. B. Moore (*loc. cit.*, p. 147) refers to Mounts Tyndall and Sedgwick as rising '1500 to 1600 feet above an elevated plateau, on which are situated Lake Dora and numerous other lakes and tarns at an altitude of 2400 feet above sea-level.' R. M. Johnston (*Proc. Roy. Soc. Tas.*, 1893, p. 100) also refers to 'the 2182 to 2400 feet plateau at their bases' (i.e., bases of Mounts Tyndall and Sedgwick). This plateau is not to be confused with the small peneplain remnant which is *part* of Mount Sedgwick.

Both they and the tillite are, however, much lower than the stripped erosion surface at Mount Sedgwick, which was also capped by Permo-Carboniferous rocks, so that one is forced to postulate either post-Palaeozoic faulting between these two sets of monadnocks, or that the post-Devonian erosion surface was as irregular as the present-day surface.

Another line of evidence suggests that the former postulate is the correct one. Thus, Voisey (1938, p. 322) places the fossiliferous marine Permo-Carboniferous (Kamilaroi) beds between Malanna and Strahan, and along the northern side of the Henty River, in his Achilles Stage, which in this area is characterized by *Fenestella* and *Spirifer*, while in the Pelion district, where it occurs at a much greater altitude, it is characterized by *Fenestella*, *Spirifer*, and *Aviculopecten*. In view of the reported occurrence of *Spirifer* and *Aviculopecten* in the Permo-Carboniferous remnant at the north-east edge of the dolerite cap of Mount Sedgwick, it seems possible that the lowermost beds of the Permo-Carboniferous at this locality also belonged to the Achilles Stage; and since there is a difference in elevation of about 3000 feet between this locality and that of the Strahan-Malanna-Henty River localities, there is a suggestion (a) that these two localities were at more or less similar elevations at the beginning of the Permo-Carboniferous period, and (b) that the more westerly part of the region was faulted down in post-Palaeozoic times. Nye and Blake (1938, p. 21) suggest that such a fault, with a throw of the order of 2000 to 3000 feet, runs parallel to and west of the West Coast Range (presumably some miles to the west), and continues as far as the north coast.

In view of the dolerite cap on Mount Sedgwick, it is presumed that such faulting did not occur until after the close of the Mesozoic.

RELATION TO THE WESTERN COASTAL PLAIN

This remnant of the Palaeozoic peneplain (erosion surface) stands at more than 1500 feet above the erosion surface which Gregory (1903, p. 179) termed the Henty peneplain, and which is now called the Western Coastal Plain (Nye and Blake, 1938, p. 4), and is regarded as having been formed during the Pliocene. The Coastal Plain is now considerably dissected as the result of rejuvenated stream action associated with changes of sea-level during the Pleistocene and Recent.

The difference in elevation between the West Coast Range and the Coastal Plain is not, however, directly due to the Tertiary faulting described above, nor as Loftus Hills (1914, p. 24) has pointed out, is it in any way connected with post-glacial uplift of the region.

The elevation of the West Coast Range conglomerates to their present position relative to the Queen River sandstones and shales in which the coastal plain is cut is thought to be due to Devonian (?) faulting, prior to the peneplanation of the area (Gregory, 1905; Edwards, 1939); and there is nothing to indicate that there has been any later fault movement. Differential erosion during the Tertiary has 'exhumed' this Palaeozoic fault line, so that the scarp which delimits the western side of the West Coast Range (Plate V, fig. 4) is probably a fault-line scarp. The eastern face of the range appears to be simply an erosion scarp; and some possibility exists that this may be true of the western scarp also, since the Queen River series may prove to be of Upper Ordovician, rather than Silurian, age (Hills and Edwards, 1941), in which case much of the evidence for the fault disappears.

Either view of the origin of the West Coast Range supports the contention of Loftus Hills (1914, p. 25) that the King River is an antecedent stream which developed on the surface of the post-Devonian sediments, and subsequently was superimposed on the West Coast Range conglomerates; and that the wide alluvial flats that mark its course at the Long Marsh are caused by the slowing up of the river where it enters its gorge tract between Mount Huxley and Mount Jukes.

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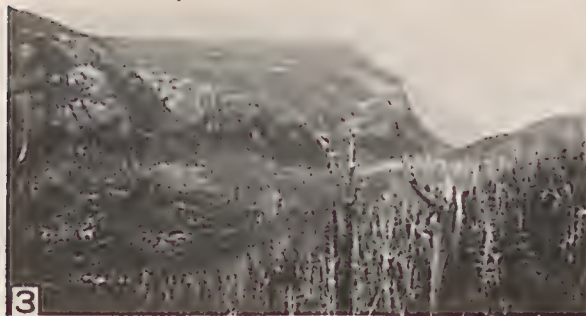
PLATE V

FIGURE 1.—Aerial view of Lake Margaret, showing the dolerite cap of Mount Sedgwick (on the right) resting on the surface of the Palaeozoic peneplain. Lake Margaret occupies a hanging valley eroded in this peneplain remnant. The dolerite-capped peaks of the Eldon Range show in the centre background. (T. F. Nankivell photo.)

FIGURE 2.—Showing the flat surface of the stripped peneplain remnant where it emerges from beneath the dolerite cap of Mount Sedgwick (eastern side).

FIGURE 3.—A U-shaped hanging valley on the eastern margin of the peneplain remnant.

FIGURE 4.—View of the southern end of the West Coast Range from the Lake Margaret haulage, showing the 'exhumed' fault-line scarp which delimits the western side of the range from the eastern margin of the Western Coastal Plain (dark foreground).



Studies in Tasmanite Shale Oil

By

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(Read 11th November, 1940)

INTRODUCTION

Although the chemical composition of petroleum has received much attention in recent years, there is a surprising lack of information from the systematic study of any one shale oil, with perhaps the exception of the work of Kogerman (1931) in Estonia, Hellsing (1921) in Sweden, and Horie (1935) in Japan, together with the various articles which have been published on the Scottish shales. However, practically no work has been published on the chemistry of Tasmanite oil and very little more on any Australian mineral oil.

The oil-producing substance of Tasmanite, seen under the microscope, consists of roundish discs that can be just discerned by the naked eye, although, as Singh (1932) has pointed out, during fossilization these spore cases have been distorted and ruptured. The general concensus of opinion is that they are innumerable sporangia which are allied to Lycopodaceous macrospores. This spore case material is the true kerogen of Tasmanite, and, in common with all shales, its pyrolysis takes place in two stages. A primary decomposition occurs, causing the kerogen to change into a gummy semi-solid bitumen of highly unsaturated nature; this bitumen is unstable at the temperature of the retort, and immediately decomposes into compounds of greater stability and saturation.

The oil taken for this research was produced by a gentle and approximate isothermal distillation of the shale, the temperature never rising above 400°C. There is little or no hydrogen sulphide produced during this pyrolysis, whereas in commercial retorting large quantities of this gas are produced. Assuming that the production of hydrogen sulphide is the result of the secondary decomposition mentioned above, the type of oil chosen for this research should give valuable information on the chemical structure of Tasmanite kerogen.

Research on shale oil presents a more difficult problem than might at first be expected; this is caused by the relatively high percentages of sulphur and nitrogen making the preparation of pure hydrocarbon mixtures very difficult indeed. Another contributing factor is the high olefine content of the oil, which causes the formation of large quantities of tarry matter when the oil is treated with sulphuric acid, in a manner which is applicable to flow oils containing a much smaller amount of this hydrocarbon type.

The crude oil possessed the following properties:—

Specific Gravity @ 15°C.	=	0.8540
Refractive Index @ 15°C.	=	1.4684
Water	=	0.34%
Tar Acids	=	4.5%
Tar Bases	=	3.2%
Sulphur	=	2.22%
Nitrogen	=	0.34%
Mercaptan Sulphur	=	0.30%
Diolefines	=	5.7%
Olefines + Aromatics	=	56.1%
Free Sulphur		not present
Hydrogen Sulphide		not present
Acetylenes		present, but not determined
Organic Peroxides		present, but not determined

The above values of the specific gravity and the refractive index; and all proceeding ones in this paper were determined in the following manner:—

The Specific Gravity was measured by means of the Westphal balance standardized against distilled water. If any small correction was thought necessary, the amount of the correction was obtained from the data published by Beale (1937).

The Refractive Index was found using an Abbé refractometer, and the temperature corrections were based on the Eykmann equation and the results of Kurtz and Ward (1936). Except where the temperature is given, both of these constants have been corrected to 20°C. All volumes are volume per cent, and all temperatures are given in degrees Centigrade and are not corrected for the emergent stem.

Distillation

The oil was fractionated in an iron drum of five gallons capacity, with an upright fractionating column at the top. This column was lagged with asbestos tape, between two layers of which was wound a helix of nichrome resistance wire, to a point 10 cm. from the top and to 23 cm. from the bottom, and by this means the column was warmed in the later stages, in order to produce a more even distillation. Inside the column, as a packing agent, were hung six one-yard lengths of brass chain. Towards the end of the distillation it was found impossible to get over the last fractions on account of the heat losses at the sides of the drum, and for this reason the last litre or so were distilled in a small apparatus of the normal laboratory type. Seventeen litres of the oil were distilled, with the results shown in the first four columns of Table I. The colour of the fractions varied progressively from colourless, in the first three fractions, through pale and dark yellow to nearly black in the last fractions.

Washing of the Fractions to Determine the Tar Acids and Tar Bases

100 ml. of each fraction were taken and poured into a stoppered separatory funnel, and an equal volume of 10 per cent aqueous sodium hydroxide added, then strongly agitated and the two layers allowed to separate out, the bottom layer run off, and the procedure repeated until the volume of the residual oil remained constant after two consecutive washings. The decrease in volume of the oil was taken as the percentage of *tar acids*. The above treatment was repeated substituting 10 per cent sulphuric acid for the caustic solution, and in this manner the amount of *tar bases* was determined. This treatment was

followed by a light sodium carbonate treat in order to remove traces of acid, then by a water wash, and finally the fractions were dehydrated over calcium chloride. The results of these treatments are shown in the Table I.

The Isolation of m-Cresol in the Tar Acids

The caustic washings from seven litres of the oil were united and the crude phenols liberated by dilute hydrochloric acid. They were redissolved in 4N caustic soda and the phenols—free from naphthenic acids—liberated by means of carbon dioxide. The reddish oily liquid was fractionated using a Young and Thomas column.

<i>Fraction No.</i>	<i>Boiling Range.</i>	<i>Density.</i>	<i>Refractive Index.</i>
1	183-204	0.9811	1.5346
2	204-207	1.0119	1.5330
3	207-217	1.0138	1.5321
4	217-226	1.0216	1.5287
5	226-233	1.0285	1.5253
6	Residues.		

The first and second fractions were united and distilled three times and divided into the following cuts:—

<i>Cut No.</i>	<i>Boiling Range.</i>	<i>Density.</i>	<i>Refractive Index.</i>
I.	200-203	1.021	1.5201
II.	203-208	1.018	1.5220
III.	208-214	1.011	1.5284

All three fractions were water-white when freshly distilled, but developed a reddish tinge after a few days. They possessed the characteristic cresol odour, and were practically sulphur free (all thiocresols possess a boiling point lower than 200°C).

Isolation of m-Cresol from Cut I

This fraction was treated with mercuric chloride in order to remove traces of sulphur compounds, washed with water, and purified by ether extraction. The purified extract was again distilled, when the major portion distilled over at $204^{\circ} \pm 0.4$. This was put aside and its characteristics found; density = 1.027 and refractive index = 1.5527, and on distillation with zinc dust it yielded toluene.

Schotten Baumann reaction with benzoyl chloride produced a benzoate of melting point 53.1° ; this corresponds fairly closely with m-tolyl benzoate of m.p. = 54° (Behal & Choay, 1894), and gave no depression of melting point when mixed with the latter substance. Another portion was nitrated according to the method of Rashig (1900) and the trinitro derivative isolated; this was light yellow in colour and melted at 104.7° ; the melting point of 2:4:6-trinitro-m-cresol = 106° .

According to Darzens (1931), anhydrous sodium acetate forms with m-cresol a complex $5.C_6H_3COONa.2C_6H_5C_6H_4OH$, which, on decomposition with water, yields m-cresol in a high degree of purity. This reaction, so the author maintains, is specific to m-cresol. A similar procedure was applied to the purified m-cresol from Tasmanite, with positive results. The m-cresol isolated had a melting point of 10.5° and refractive index of 1.5343 at $20^{\circ}C$, agreeing very closely with the data published by Darzens. All attempts to detect the ortho- and para-isomers were unsuccessful.

THE OLEFINE CONTENT

The determination of the correct olefine content is a matter of great difficulty in an oil such as this. Owing to the colour of the middle and last fractions, methods such as that of Mulliken and Wakeman (1935), involving the use of bromine, could not be used, as even the middle fractions had sufficient yellow colour to mask completely the very similar colour of the bromine. Moreover Thomas, Bloch, and Hoestra (1938) suggest that bromine absorption does not give correct values for the unsaturation when diolefines are present, which is undoubtedly the case in this oil. The use of the Francis bromide-bromate solution (Francis, 1926) was tried in the lower fractions without concordant results, probably due to the presence of cyclic olefines, which, according to Cortese (1929) give anomalous results.

After trying several reagents it was decided to employ sulphuric acid without the addition of boric acid as suggested by Kattwinkle (1927), as this has been shown incorrect by Tropsch and others (1929). It was fully realized that this method possessed many inherent disadvantages, such as the formation of polymerization products, attack on other substances, also the constitution of the saturated hydrocarbons is not necessarily the same before and after the sulphuric acid treatment, as new paraffins and naphthenes may be formed under the influence of the acid (Brochet, 1893).

OPTIMUM ACID STRENGTH FOR OLEFINE DETERMINATION

In order to gain some idea of the action of different strengths of sulphuric acid on the oil, a representative fraction was treated with gradually increasing strength sulphuric acid, in the manner suggested by Fisher and Eisner (1937). The results of this are shown below:

<i>Acid Strength.</i>	<i>Residual Volume.</i>	<i>Refractive Index.</i>
%	ml.	
....	100	1.4812
70	93.0	1.4778
75	88.0	1.4785
80	82.5	1.4796
82.5	80.5	1.4800
85	76.6	1.4820
88	60.5	1.4795
90	58.0	1.4765
96	51.0	1.4583
100	44.5	1.4364
105	39.5	1.4385

From these figures it can be seen that there is incipient attack on the aromatics when the acid strength has reached 88 per cent and that complete removal of aromatics and the commencement of attack on the paraffin-naphthene mixture starts with the 100 per cent acid.

50 ml. of the acid and base-free oil were placed in a stoppered separatory funnel and treated with an equal volume of 85 per cent sulphuric acid for ten minutes with external cooling, the acid layer separated off, and the treatment continued until the volume of the residual oil was constant. The results are given in Table I.

The residual oils were water-white, had practically no odour, and did not decolourize a weak solution of potassium permanganate.

The presence of Diolefines

The presence of appreciable amounts of diolefines in the oil was indicated by the intense yellow colour in some fractions. A certain fraction, in which the presence of diolefines was strongly suspected, was placed in a flask with 20 per cent of its weight of maleic anhydride and kept at a temperature of 100°C. for four hours under reflux. At the end of this period the residual oil was decanted off and the crystals washed free from oil; these crystals were soluble in alcohol and melted at 145°. To prove that ring formation had actually taken place, 1.5 gm. of the maleic anhydride compound was heated with 2 gm. of resorcinol and 1 gm. of zinc chloride for several hours. The product of this reaction was an intense red solid, soluble in alcohol, and had a characteristic colour change from acid to alkaline solution. The formation of this coloured substance (to be assumed of the phthalein type) could only arise from a cyclic structure, necessitating ring closure between the maleic anhydride and the diolefine with the formation of an acid similar to terephthalic acid and the subsequent formation of the anhydride.

The Presence of Terpene-like Olefines

A series of investigations were carried out in order to determine whether terpenes or substances allied to them were present in the oil. It is not intended to give a detailed description of the work done in this direction, but to state briefly that no conclusive evidence for their presence was obtained, although certain lines of research produced promising results, notably halogenation, followed by treatment with mercuric acetate.

THE SULPHUR COMPOUNDS

Sulphur is always present in shale, and, in general, a similarity exists between the sulphur compounds in shale oil and those in petroleum, but it is found that aromatic compounds predominate in the oil from shale in contrast to the usual aliphatic nature of the sulphur compounds in petroleum.

An examination of the more important sulphur compounds occurring in shale oil will serve to show that they are essentially thiophenic in nature and for this reason investigations on the sulphur bodies in shale oil are usually more difficult than the corresponding work on petroleum. This is more easily realized when the unsaturated nature of the former is taken into account.

On an allied oil Morgan and Soule (1923) write, 'There is no concentration of sulphuric acid capable of removing such sulphur compounds without attacking the unsaturates which predominate in the neutral oil. These unsaturated compounds, moreover, interfere with the usual qualitative thiophene identifications, by reacting with the sulphuric acid of the indophenin test and with the nitric acid of the thalline test to give reddish brown shades which mask the colour reactions, even in the presence of added thiophene.'

The presence of sulphur compounds in an oil which is to be used for power purposes has been one of the great disadvantages against the employment of shale oil in this connexion, for not only does the sulphuric acid formed during its combustion have a corrosive effect on the cylinders of the engine, but recently Kruser and Schade (1933) have shown that such compounds can act as accelerators in gum formation.

Challenger (1926) and Schleiber (1915, 1916) have performed important investigations into the nature of the sulphur compounds occurring in shale oil; both of the above investigators have shown that these bodies are mainly derivatives of thiophene, and have succeeded in isolating thiophene itself and certain of the lower alkyl homologues.

EXPERIMENTAL

Mercaptans

Mercaptan sulphur was estimated by a modification of the method proposed by Bond (1933). The results are given in the first table.

The Thiophenes

Five litres of crude Tasmanite gasoline were given a light acid and alkali wash and then distilled with the following results:—

<i>Fraction.</i>	<i>Temperature Range.</i>	<i>Volume mls.</i>	<i>Density @ 18°.</i>	<i>Refractive Index.</i>	<i>Sulphur % by Wt.</i>
1	-50	9.6	0.6934	1.3834	0.20
2	50-70	87	0.7037	1.3972	0.53
3	70-90	457	0.7484	1.4088	1.18
4	90-110	491	0.7641	1.4207	1.51
5	110-130	538	0.7884	1.4364	1.97
6	130-150	593	0.7928	1.4389	2.31
7	150-160	163	0.8049	1.4469	3.06
8	160-170	161	0.8112	1.4496	3.58
9	170-180	115	0.8225	1.4558	3.24
10	180-190	91	0.8377	1.4590	3.22
11	190-200	58	0.8400	1.4654	3.02
12	Residues.				

Fractions 3 and 4 were united and subjected to more exact fractionation, thus:—

<i>Fraction.</i>	<i>Temperature Range.</i>	<i>Density.</i>	<i>Refractive Index.</i>	<i>Sulphur % by Wt.</i>
3a	70-75	0.7179	1.4003	1.02
3b	75-80	0.7295	1.4073	1.18
3c	80-85	0.7583	1.4232	1.48
3d	85-90	0.7667	1.4180	1.54
4a	90-95	0.7548	1.4205	1.48
4b	95-100	0.7585	1.4300	1.49

The Presence of Thiophene in Fractions 3c + 3d

A representative portion of these two fractions was again distilled and cut at 2° intervals. The 83°-85° cut was treated with mercuric chloride in the following manner:—Alcohol was added to the fraction until the solution contained 80 per cent alcohol, and to it was added twice the amount of mercuric chloride required to form the mercurichloride (assuming that all the sulphur was contained in the thiophene), and five times the quantity of sodium acetate necessary to combine with the liberated hydrochloric acid. It was allowed to stand for two days with frequent shaking, and at the end of this period the precipitate was filtered off. A portion of this precipitate after purification gave, on analysis:—

Chloride	11.8% found; 11.1 calculated
Sulphur	9.7% found; 10.0 calculated

The melting point of the compound was rather indefinite near 179° , and at 183° it commenced to blacken. The melting point of thiophene mercurichloride is reported by Steinkopf to be 183° . Another portion of the precipitate on distillation with 6N hydrochloric acid decomposed to produce a liquid which reacted positively to the usual thiophene colorimetric tests.

The Methyl-Thiophenes

Fractions 4b and 5 were united and distilled three times.

<i>Fraction No.</i>	<i>Temperature Range.</i>	<i>Density.</i>	<i>Refractive Index.</i>	<i>Sulphur % by Wt.</i>
MT (i)	105-109	0.7642	1.4246	2.43
MT (ii)	109-117	0.7759	1.4345	2.98
MT (iii)	117-126	0.7808	1.4348	2.27

Lot MT(ii) was fractionated twice, and the final temperature limits taken at 111° to 115° . The volume of this fraction was 67 ml., and it contained 2.99 per cent sulphur. 60 ml. of this were dissolved in a litre and a half of alcohol and agitated with one litre of aqueous sodium acetate (33 per cent) and four litres of saturated aqueous mercuric acetate. After two and a half hours a dirty yellow precipitate formed; this was removed, and further precipitation allowed to take place. At the end of one day the combined precipitates were extracted with boiling alcohol and the solute crystallized and purified. The crystals melted between 202° and 204° . Steinkopf (1914) states that the melting point of 2-methylthiophene-5-mercurichloride is 204° with previous sintering, while the corresponding figure for the 3-methyl isomer is quoted at 138° . The methylthiophene-mercurichloride was decomposed with hydrochloric acid as before, and a portion of the liberated methylthiophene converted into its tribromo derivative. On recrystallization a sharp melting point was obtained at 85.6° . The melting point of tribromomethylthiophene is recorded in the literature at temperatures varying between 87° and 94° but most reliable sources place it at 86° . The melting point of the other isomer is 35° , while Gatterman (1885) states that a mixture of the two isomers cannot be separated by crystallization and melts at 74° . In order to complete the identification a small portion of the purified compound was oxidized to the corresponding acid with potassium permanganate. The melting point of this acid (126°) clearly corresponded to 2-thiophenecarboxylic acid.

Examination of Fraction 6 for Dimethylthiophenes

Fraction 6 was distilled several times and finally cut into two lots:—

6 (a) 130° - 135° Density, 0.7854; Refractive Index, 1.4390.

6 (b) 135° - 143° Density, 0.8012; Refractive Index, 1.4468.

No thiophene derivatives could be found in the first lot. The other lot, 6(b), gave very peculiar results. 60 ml. were treated with mercuric acetate as before, and, within a half hour, a large amount of white granular precipitate was formed. The mixture was allowed to stand for thirty hours with frequent shaking, after which the precipitated mercury compounds were filtered off. An examination of the filtrate showed that the whole of the fraction had been converted into the mercury compound. The precipitate was washed with petroleum ether, after

which it was distilled with 6N hydrochloric acid, whereupon 57 ml. of a sweet aromatic oil were recovered. The oil burnt with a very smoky flame, and possessed the following properties:—

Density	0.8107
Refractive Index	1.4471
Sulphur	3.0 per cent

It reacted negatively to the usual thiophene tests. On distillation the whole of the distillate came over between 136° and 140°, which immediately precludes other sulphur containing substances, such as thioethers, thiols, thiophanes, &c., none of which have been reported to boil within these limits. In the case of 2:3-dimethylthiophene-mercurichloride, there is a direct covalent link between the mercury and carbon atoms, in contrast to the addition compounds formed when mercury salts act on other sulphur compounds, such as mercaptans. This latter type is split up on treatment with caustic alkalis with the formation of the oxide of the metal. It was proved in the present case that the compound under consideration was essentially aromatic in nature. However, at this juncture it seems inadvisable to assume that dimethylthiophenes are absent, nevertheless it appears that another type of sulphur compound is present in such large quantities that the usual methods used in the isolation of thiophene homologues are not applicable. It is hoped to continue this phase of the research in the future.

These investigations were carried out in the Department of Chemistry in the University of Tasmania during the tenure of a Commonwealth Government Research Scholarship (1938 and 1939).

SUMMARY

Tasmanite shale on gentle pyrolysis produces an unsaturated oil with a relatively high aromatic content. The oil was fractionated and the physical properties of the different fractions found, after which the fractions were washed with sodium hydroxide solution and dilute sulphuric acid, in order to determine the tar acids and tar bases. The isolation of m-cresol from the tar acids is described. The degree of unsaturation, as determined by 85 per cent sulphuric acid, varied between 40 per cent and 47 per cent, including as much as 11 per cent diolefines. It is probable that terpenes, or substances closely allied to them, occur in the oil, although their presence was not confirmed. Tasmanite shale oil contains large quantities of sulphur, the major portion of which is contained in heterocyclic molecules. The cyclic sulphur bodies in the lower fractions were thiophenic in nature and the presence of thiophene and methyl thiophene was confirmed.

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TABLE I.

Fraction.	Temperature Range.	Volume ml.	Specific Gravity @ 20°.	Refractive Index @ 20°.	Tar Acids.	Tar Bases.	After Removal of Acids and Bases.			Mercaptan Sulphur.
							Specific Gravity.	Refractive Index.	Olefines Per cent.	
A	36-60	60	0.6799	1.3857	0.0	0.5	0.6800	1.3858	40	0.000
B	60-70	414	0.6958	1.4038	0.0	0.5	0.6959	1.4039	40	0.029
C	70-80	162	0.7199	1.4046	0.0	1.0	0.7200	1.4048	46	0.014
D	90-100	227	0.7200	1.4060	0.0	1.1	0.7195	1.4063	47	0.074
E	100-110	125	0.7237	1.4097	0.0	1.0	0.7230	1.4098	46	0.105
F	110-120	256	0.7425	1.4130	0.0	1.1	0.7415	1.4130	45	0.082
G	120-130	261	0.7531	1.4205	0.0	1.1	0.7528	1.4200	41	0.115
H	130-140	497	0.7630	1.4242	0.1	1.4	0.7649	1.4254	45	0.126
I	140-150	544	0.7665	1.4284	0.3	1.6	0.7665	1.4286	45	0.164
J	150-160	529	0.7785	1.4329	0.4	2.0	0.7806	1.4330	44	0.232
K	160-170	956	0.7934	1.4418	0.5	2.4	0.7897	1.4380	42	0.273
L	170-180	841	0.8062	1.4468	1.5	2.5	0.8004	1.4419	40	0.282
M	180-200	910	0.8148	1.4523	2.0	2.5	0.8154	1.4494	40	0.226
N	200-220	2022	0.8298	1.4607	3.0	2.7	0.8277	1.4567	41	0.390
O	220-240	1920	0.8461	1.4657	3.5	3.5	0.8396	1.4612	40	0.507
P	240-260	1873	0.8713	1.4805	3.5	4.0	0.8668	1.4758	40	0.224
Q	260-280	822	0.8779	1.4848	4.5	4.0	0.8763	1.4832	40	0.392
R	280-300	864	0.8803	1.4932	5.0	4.5	0.8764	1.4906	41	0.421
S	300-320	778	0.8978	1.4992	5.0	4.5	0.8958	1.4974	41	0.438
T	320-340	843	0.9161	1.5077	5.5	4.5	0.8999	1.5056	40	0.515
U	340-360	705	0.9328	1.5183	5.5	4.0	0.9311	1.5170	40	0.344
V	360-	175	0.9514	1.5227	5.8	4.0	0.9500	1.5213	40	0.445

Observations on the Stem Anatomy of the Genus *Richea*(¹)

By

WINIFRED M. CURTIS

(Read 11th November, 1940)

PLATE VI

The *Richeas* are essentially Tasmanian plants: widespread and abundant in mountain habitats, certain species are important members of the Austral-Montane formation of mountain plateaux. The genus *Richea*, R. Br., in which Rodway (1903) includes the genera *Cystanthe* and *Pilitis* of Hooker (1860), comprises eight species: of these, seven are endemic in Tasmania, while one, *R. Gunnii*, common in Tasmania, is found also in the Australian Alps. The species listed by Rodway are:—*R. sprengelioides*, F.v.M., *R. procera*, F.v.M., *R. acerosa*, F.v.M., *R. Milligani*, F.v.M., *R. Gunnii*, Hook., *R. scoparia*, Hook., *R. dracophylla*, R. Br., *R. pandanifolia*, Hook.

The following description is based on the examination of fresh material of all the above species except of *R. Milligani*, for which herbarium material was used. Specimens of the plants collected have been placed in the herbaria of the Royal Botanic Gardens, Kew, and of the University of Tasmania.

The plants are erect evergreen shrubs, ranging in height from 1 ft., in specimens of *R. sprengelioides*, to more than 30 ft., in specimens of *R. pandanifolia*. The leaves, which show a corresponding range in size, from $\frac{1}{2}$ inch to several feet in length, are xeromorphic and densely crowded on the stems. The phyllotaxis is $\frac{2}{5}$ or $\frac{5}{13}$. The arrangement of the leaves in *R. sprengelioides* is illustrated in Plate VI, fig. 1. A certain degree of variation in the size and habit of the leaves, which may be erect or recurved, is noticeable in the species *R. sprengelioides* and *R. scoparia*. The leaves of all the species are, however, characterized by wide decurrent sheathing bases, which, when shed, leave conspicuous annular scars. This feature readily distinguishes the *Richeas* from the closely allied *Sprengelia incarnata*, Sm.

In all the species of *Richea*, the stems in transverse section show the typical dicotyledonous structure. Growth is slow and secondary thickening may occur at a distance of less than 1 cm. behind the apex. The xylem vessels are small, and regularly arranged: the walls are strongly lignified having bordered pits or scalariform thickening. The vascular tissue is traversed by uniseriate rays.

The structure of the pith and of the primary cortex is of interest. In these regions special excretory receptacles containing large solitary crystals of calcium oxalate, are a prominent feature. The receptacles, consisting of groups of two to sixteen relatively large cells which are crystal sacs, are interspersed between the smaller, thicker-walled cells of the pith and cortex. The crystal sacs have thin cellulose walls, some of which, in the older parts of the stem, may partially

(¹) Published under the auspices of the Tasmanian Biological Survey.

break down (Plate VI., figs. 2 & 3). While the structure of the receptacles is similar in the pith and in the primary cortex, in the pith the surrounding cells have strongly lignified walls perforated by simple pits, in the cortex the thickening of the corresponding cells is cellulose. These thickened cells of the ground tissue are irregular in shape. The individual cells when isolated by maceration for a few days in a mixture of 10 per cent chromic and nitric acids, are seen to have projections which may interlock with similar outgrowths from adjoining cells (Plate VI, fig. 4). The differentiation of the cells of the pith takes place at an early stage, cells developing into crystal sacs may readily be distinguished in sections taken a few mm. behind the apex of the shoot.

Excretory receptacles, which are a characteristic feature of the stems of every species of *Richea*, are not found in *Sprengelia incarnata*, and they provide an interesting anatomical distinction between these plants. Such receptacles are not described by Solereder (1908) in his account of the anatomical features of the Epacrideae, although a reticulate arrangement of large and small cells in the pith of *Richea* is noted.

Cork formation in the stems of the Richeas, as in other members of the family, begins in a deep-seated layer. In every species of *Richea* this is in the phloem immediately within the pericyclic fibres. Solereder states that in the Epacrideae no distinct cork cambium is present and 'it almost appears as though the cells of the cork originated from the outer cells of the soft bast'. In the material now examined, although a meristematic layer may be distinguished, this is somewhat irregular, and the cells cut off by it are not characterized by a radial arrangement. After four to eight rows of cork cells are formed, the activity of more deeply seated meristematic layers results in the formation of successive cork cylinders (Plate VI, fig. 5).

I am glad to have this opportunity of expressing my thanks to Dr. H. D. Gordon, who suggested the examination of this Tasmanian genus, and to the Committee of the Biological Survey of Tasmania who defrayed the cost of collecting the material. The problem arose during the course of investigations carried out whilst in receipt of a Commonwealth Research Grant.

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PLATE VI

FIGURE 1.—Leafy stem of *Richea sprengelioides*. Nat. size.

FIGURE 2.—T.S. of stem of *R. dracophylla*, showing crystal sacs in the pith.

CS crystal sac.

C crystal of calcium oxalate.

FIGURE 3.—L.S. of stem of *R. dracophylla*, showing crystal sac in pith.

FIGURE 4.—*R. dracophylla*. Cells of ground tissue of pith, isolated by maceration.

Figs. 1-4 made with camera lucida, X 162.

The pitting of the cells of the ground tissue is shown in two cells only in each diagram.

FIGURE 5.—*R. procera*. T.S. of stem showing formation of cork.

Drawn with camera lucida, X 312.

co cortex

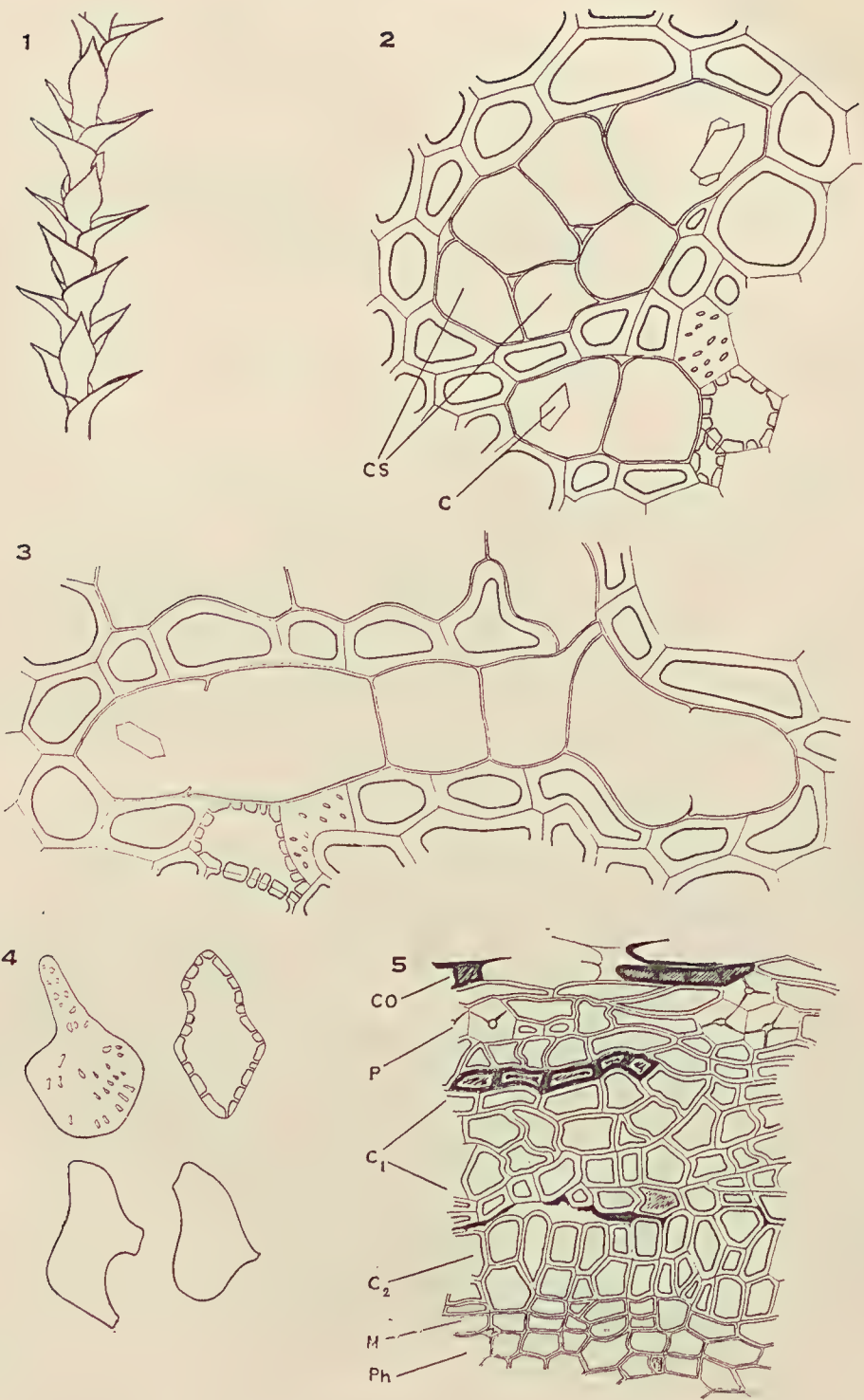
p pericycle

c₁ first zone of cork

c₂ second zone of cork

m meristematic layer

ph phloem



The Morphology of *Tettigarcta tomentosa* White, (Homoptera, Cicadidae) ⁽¹⁾

By

J. W. EVANS, M.A., D.Sc., F.R.E.S.

(Read 11th November, 1940)

For a long time great interest has been shown in Australian cicadas belonging to the genus *Tettigarcta* White. This is because of certain primitive features of their structure and their wide divergence from all the rest of the Cicadidae. In spite of this interest their detailed morphology is largely unknown, and only a few specimens are to be found in the museums of the world.

In 1937 a biological survey of the fauna of Tasmania was initiated, and collectors in country districts were asked to keep a special watch for the 'Hairy Cicada'. As a result a few specimens were acquired in 1939, and in the following year nearly fifty specimens were procured, all from one locality. The present study is concerned with those features of the morphology of *Tettigarcta* that are of especial interest from the standpoint of comparative morphology.

NOMENCLATURE AND SYSTEMATIC POSITION

The genus *Tettigarcta* and the genotype *Tettigarcta tomentosa* were described by Adam White (1845) in an appendix to 'Eyre's Expeditions and Discoveries in Central Australia.' Excellent figures of an immature and adult insect accompanied the descriptions, but the only locality recorded was 'Australia'. In the following year, White (1846) re-described in almost identical words, both the genus and the species, on this occasion giving the locality as 'Australia, near Melbourne'.

Many years later Distant (1883) described a second species in the genus, which he named *Tettigarcta crinita*. *T. crinita* differs from the genotype in having the lateral angles of the pronotum rounded instead of pointed. Distant was not aware from what part of Australia his specimen originated. Froggatt in 1903 described a specimen of *T. tomentosa* which he had received from Tasmania, and in the following year with Goding (Goding and Froggatt, 1904) re-described the genus and both species. These authors were of the opinion that *tomentosa* was confined to Tasmania and *crinita* limited to Victoria. Ashton (1924) later extended the range of *crinita* to Mt. Kosciusko in New South Wales. Since the genotype is, as may be seen from the original illustration, clearly the Tasmanian species, and as Eyre did not visit Tasmania, one is forced to the conclusion that White was misled as to the place of origin of the specimens he described.

(1) Published under the auspices of the Tasmanian Biological Survey.

Distant (1906) placed the genus in the Division Tettigarctaria of the sub-family Tibicinae. Myers (1929), however, rightly considered it merited sub-family rank and accordingly created the sub-family Tettigarctinae for its sole reception.

DESCRIPTION AND HABITS

Both species are medium-sized, dull or reddish-brown cicadas, with a wing expanse of about three inches. *T. crinita* is slightly larger than the genotype. The fore-wings are suffused with pale brown or reddish-brown and the distal divisions of the veins may be surrounded by dark-brown markings. The most striking superficial characteristics are the extreme hairiness of the body and the small head in relation to the very large pronotum.

Although these cicadas are especially associated with high altitudes, they have also been taken close to sea-level. Ashton caught several specimens of *T. crinita* in February (summer) on Mt. Kosciusko at a height of 5000 feet. Most of the specimens of *T. tomentosa* received by the Tasmanian Biological Survey were from Tarraleah, which is at an altitude of 2500 feet. These were obtained during May and June (winter), being attracted to lights even on cold frosty nights; a few were seen flying at dusk. During the day they shelter under bark. Emergence from nymphal exuviae takes place at night and insects have often been seen early in the morning with their wings not fully developed. With other cicadas it is also usual for transformation from nymphs to adults to occur during night-time.

MORPHOLOGY (*T. tomentosa*)

The Head

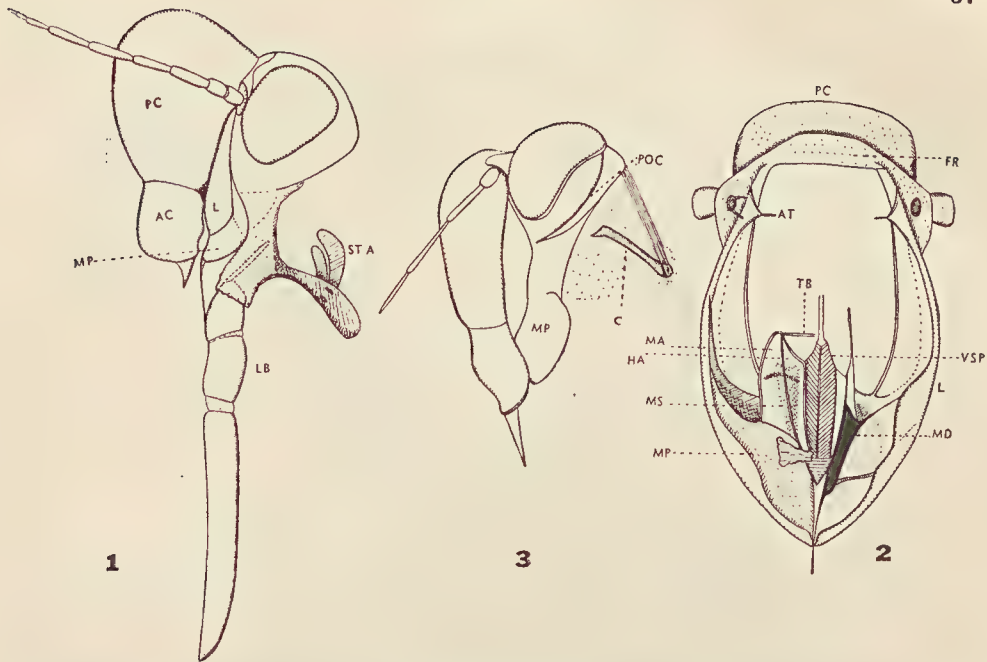
The morphology of the head of cicadas has been dealt with fully by Myers (1928). The present author's interpretation of homopterous head-structure differs from that of Myers in several respects and has been given in an earlier paper, (Evans, 1939).

Fig. 1 represents the head of a mature nymph in lateral aspect. The antennae have nine segments, which is more than possessed by other cicadas. Attention is directed to the attachment of the labium anteriorly to the head just behind the maxillary plates and posteriorly to the floor of the prothorax. The sternal apophyses of the prothorax are shown in the figure.

Fig. 2 illustrates the head of a nymph viewed from behind. The eyes and vertex have been removed, also the maxillary plate and its stylet and apodeme, and the apodeme of the hypopharynx from the right hand side revealing the attachment of the mandible to the inturned margin of the lorum. The adult head (fig. 3) differs from that of the nymph in the reduction of the number of antennal segments to four and the flattening of the clypeus. It remains long and narrow and does not become wide as is usual in cicadas. The labium also remains long and reaches to beyond the hind coxae.

The Thorax

The head and thorax of *T. tomentosa* in dorsal aspect are illustrated in fig. 4. The only part of the pronotum to which muscles are attached is the anterior third immediately behind the eyes; the rest freely overlaps the mesonotum. Myers states that the hypertrophied pronotum of *Tettigarcta* overshadows the much reduced mesonotum. Actually the mesonotum is in no way reduced, only concealed, and the condition in *Tettigarcta* resembles that usual in Homoptera apart from the Cicadidae, where the only part of the thorax that is visible dorsally is the pronotum and the triangular scutellum of the mesonotum.



Tettigarcta tomentosa

- FIG. 1.—Head of nymph in profile. pc., post-clypeus; ac., ante-clypeus; l., lorum; mp., maxillary plate; lb., labium; sta., sternal apophyses.
- FIG. 2.—Head of nymph from behind after the removal of the vertex and the eyes, the maxillary plate and its attachment have also been removed from one side. fr., frons; at., at base of anterior tentorial arms; tb., body of the tentorium; ma., maxillary apodeme; ha., hypopharyngeal apodeme; ms., maxillary stylet; md., mandibular stylet; vsp., ventral surface of the sucking-pump. Other lettering as in Fig. 1.
- FIG. 3.—Head of adult in profile. poc., postoccipital suture; cs., cervical sclerite. Other lettering as in Fig. 1.



FIG. 4.—*Tettigarcta tomentosa*. Head, pronotum and scutellum in dorsal aspect.

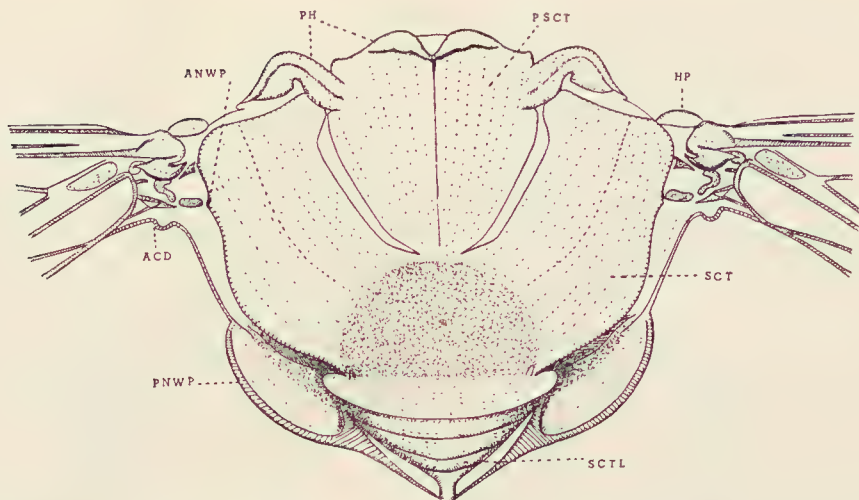


FIG. 5.—*Tettigarcta tomentosa*. Mesonotum and axillary sclerites of the forewing after removal of the pronotum. ph., phragma; psc., prescutum; anwp., anterior notal wing process; hp., humeral plate; pnwp., posterior notal wing process; sc., scutum; sctl., scutellum; acd., axillary cord.

If the pronotum is removed the mesonotum is disclosed, (fig. 5). I am doubtful as to the exact limits of the prescutum. Apart from the apical scutellum, the mesonotum is divided into two parts by wide sutures. These sutures separate the attachments of the median dorsal longitudinal muscles and the tergo-sternal muscles of the fore-wings. Both Myers and Beamer (1928) consider the whole of the central U-shaped area to be the prescutum. Snodgrass defines the prescutum as a narrow transverse strip behind the antecostal suture which may end in pre-alar bridges. Imms (1925) figures the mesotergum of a tipulid, and labels the large anterior area 'prescutum', whilst Rees and Ferris (1939) name the same area in another tipulid 'scutum'.

It is suggested that the narrow anterior thickening of the notum, labelled 'phragma' in fig. 5, is the acrotergite and that the bent lateral ridges, also labelled 'phragma', are pre-alar bridges. These are fused ventrally with the anepisterna of the mesopleuron on each side. The prescutum is then an area behind the acrotergite, between the pre-alar bridges, and is not defined posteriorly; most of the centre of the U belongs to the scutum. The posterior median area of the scutum (shaded in the figure) is depressed and the scutellum is raised and narrows apically. The latter completely conceals medially, not only the metanotum, but also the first and second abdominal segments. From the re-curved apex of the scutellum a large vertical phragma descends; to it are attached the median dorsal longitudinal muscles of the fore-wings. The metanotum, which is reduced, is not figured. The pleural and sternal surfaces of the thorax of a mature nymph are illustrated in figs. 6 and 7. Recent work by Ferris (1940) has added considerably to the comprehension of the structure of the insect thorax, and Ferris' interpretation has been adopted in the present paper.

In fig. 7 the thorax has been cut dorsally and the severed sides flattened out. In the prothorax the sternal apophyses arise from separate pits and are free distally. The pleural apodeme is short, wide, and strong, and bears a long narrow apophysis. The mesothorax retains its primitive structure to a greater extent

than the rest of the thorax. Both the episternum and epimeron are undivided, a trochantin is present, and a meron separated off from the base of the coxa. The sternal apophyses arise from separate pits at the posterior apex of a triangular sclerotized area, the true sternite. In the metathorax the sternal apophyses arise from a single pit.

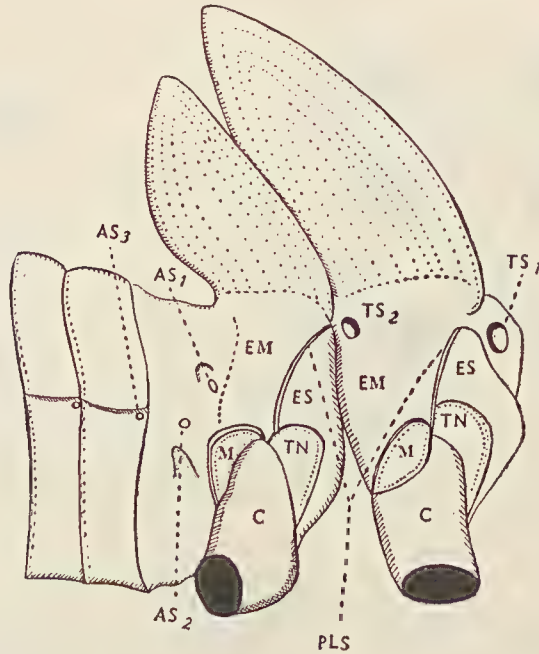
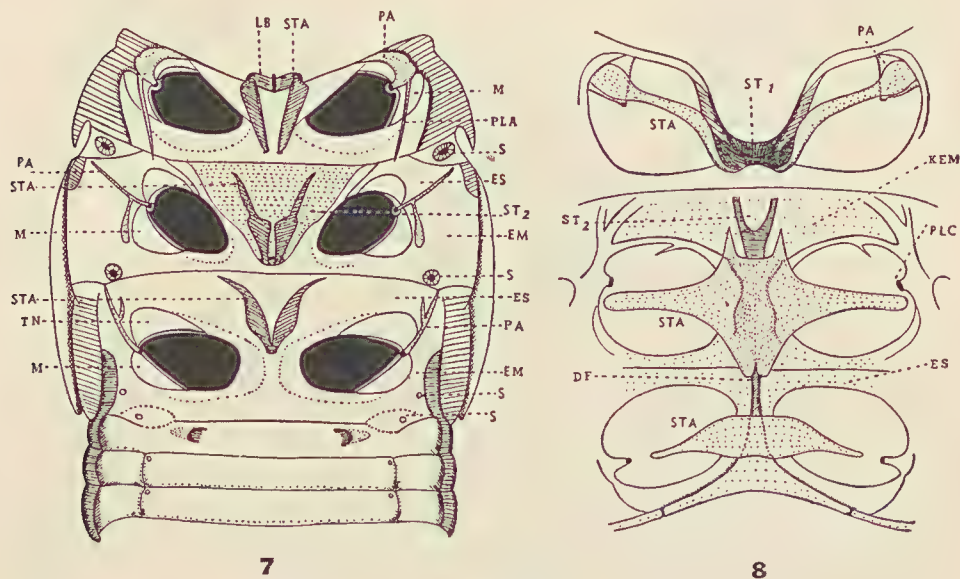


FIG. 6.—*Tettigarcta tomentosa*. Lateral aspect of the meso- and metathorax and anterior four abdominal segments of a nymph; the wing pads are folded back. ts., thoracic spiracle; es., episternum; em., epimeron; tn., trochantin; m., meron; c., coxa; pls., pleural suture; as., abdominal spiracle.

The structure of the thorax of an adult insect is shown in figs. 8, 9, 14, and 15. The sternal apophyses of the prothorax are fused to the anterior lateral margins of the leg-cavities and the pleural apodemes on each side. The sclerotized area between the apophyses is labelled 'Sternum 1', but it is uncertain whether it contains any elements of the true sternum. In the mesothorax the episternum is divided into an anepisternum, a katepisternum and a pre-episternum. The pre-episterna of the two sides meet mid-ventrally at the discriminal line, leaving anteriorly a small triangular area, the remnant of the sternite of the nymph. Ferris has defined the discriminal line as the line of meeting mid-ventrally of the sub-coxal elements of the two sides of the body. The large sternal apophyses of the mesothorax arise from the posterior continuation of the discriminal fold; they are free apically. Myers recognises and figures a separate 'median division of the episternum' of the mesothorax in cicadas. In *Tettigarcta* there is a partial division of the episternum into three parts, laterally by a cleft or suture and medially by a furrow with an internal ridge. Neither completely divides the sclerite, and it is believed that both are secondary developments. The epimeron is divided into an anepimeron and katepimeron. In the metathorax the episternum

is undivided and the episterna of the two sides meet mid-ventrally at the discriminal furrow. The epimeron consists of an anepimeron and katepimeron and a narrow post-coxal sclerite is articulated with the posterior ventral prolongation of the latter.



Tettigarcta tomentosa

FIG. 7.—Thorax and anterior abdominal segments from above, internal aspect. pa., pleural apodeme; pla., apophysis of pleural apodeme; s., spiracle; st., sternum; other lettering as in previous figures.

FIG. 8.—Internal ventral view of the adult thorax to show sternal apophyses. df., discriminal fold; plc., pleural condyle; other lettering as in previous figures.

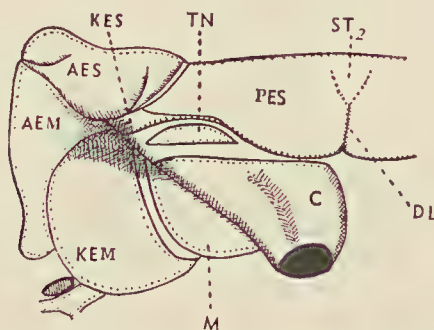


FIG. 9.—*Tettigarcta tomentosa*. Left pleuron and coxa of adult mesothorax. aes., anepisternum; kes., katepisternum; pes., pre-episternum; aem., anepimeron; kem., katepimeron; dl., discriminal line. Other lettering as in previous figures.

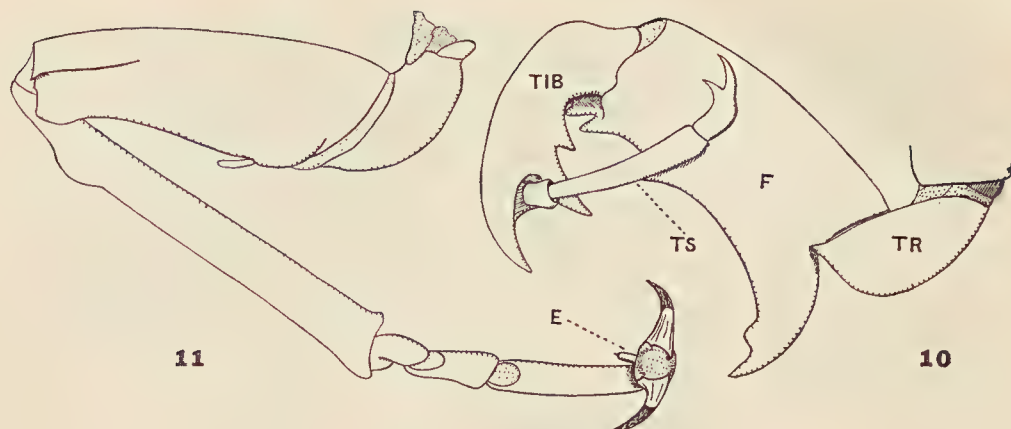
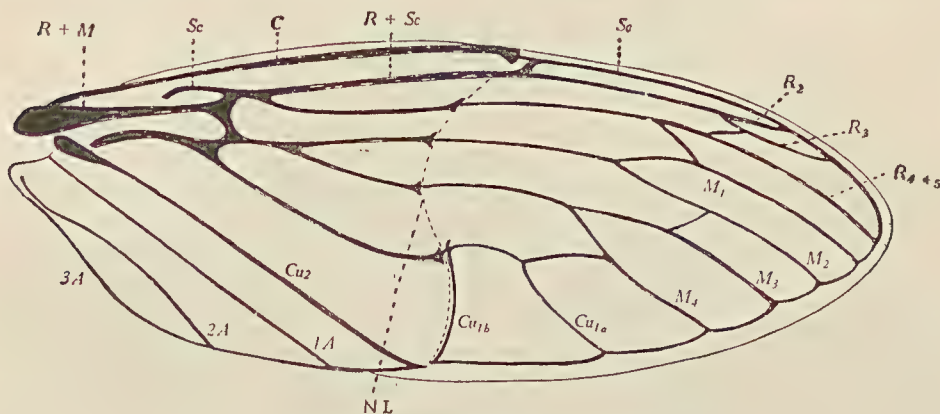
*Tettigarcta tomentosa*

FIG. 10.—Foreleg of nymph. ts., tarsus; tb., tibia; f., femur; tr., trochanter.
 FIG. 11.—Foreleg of adult. e., empodium.

The Legs

The fore-leg of a mature nymph and of an adult insect are figured (figs. 10 and 11). The tarsus of the nymph has two segments and the claws, which are of different sizes, are fused basally. In the adult leg the femur is not so broad as is usual with cicadas and bears a single finger-shaped process. All three pairs of legs are remarkably long and empodia are present.

FIG. 12.—*Tettigarcta tomentosa*. Forewing.

The Wings

The wings are steeply tectiform and meet close behind the apex of the scutellum when at rest. The forewings are wrinkled and coriaceous and lack cross-ridgings; the veins are hairy. The venation is of extreme interest. In the fore-wing (fig. 12) the costal vein lies a little below the anterior margin; it is preceded in the nymph by a strong vein containing a trachea. There is a considerable space in the nymphal wing-flap between the costal vein and a group of three trachea that lie below it. The upper of these represents the sub-costal vein. This vein in the adult is convex on the lower surface of the wing proximally, thence it appears on

the upper surface, and is fused with the upper branch of the radial sector as far as the nodal line. From this point it lies just inside the margin of the wing and appears to be continuous with the costal vein. The upward turn of the sub-costal trachea at the nodal line can be seen clearly in the nymph. Accepting Comstock's (1918) statement that R_1 is not present in the Cicadidae, the trachea that immediately adjoins Sc and divides into two well before the nodal line, must represent the radial sector, the upper branch of which, as has already been stated, is fused for part of its length with the sub-costal vein in the adult wing. All four branches of the median vein are developed, and there is a third anal vein. The nodal line consists of a line of weakness that extends across the wing in the position shown. Where the veins cross the line they break and appear re-joined on the ball and socket principle. The significance of the line is discussed in a later section.

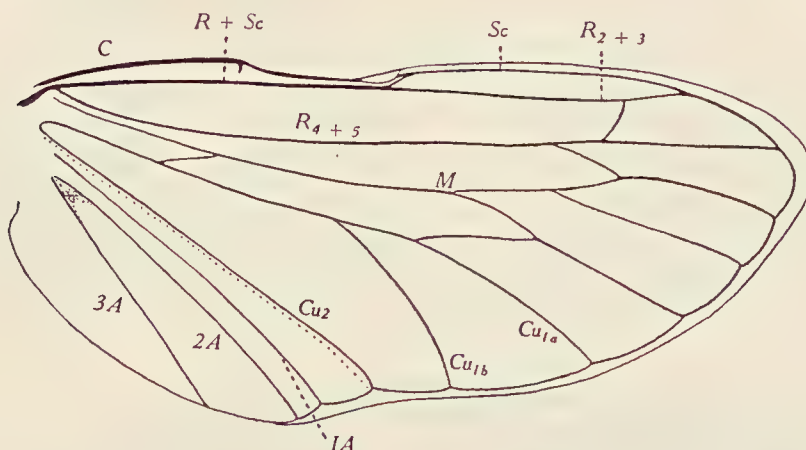


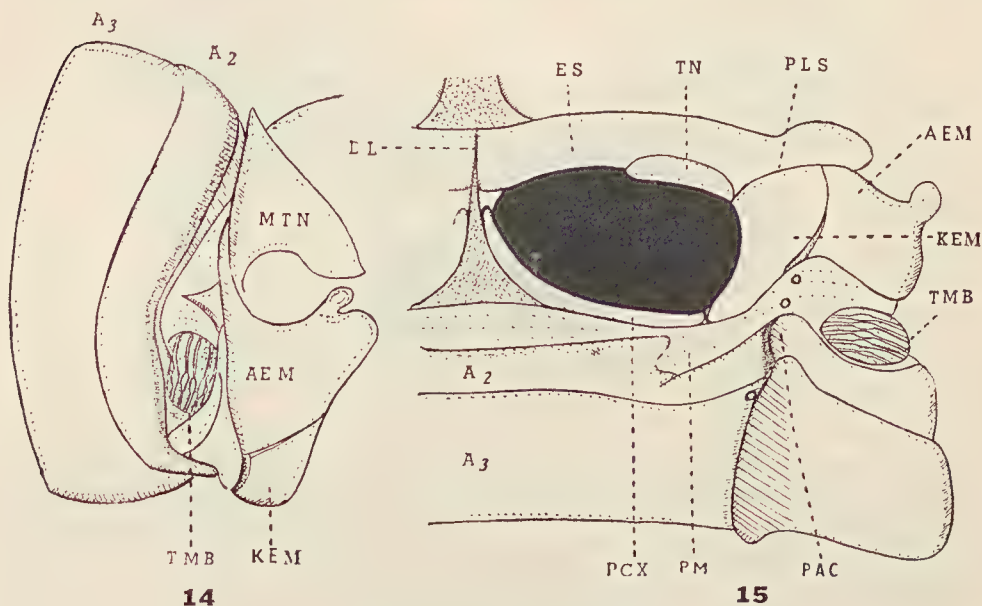
FIG. 13.—*Tettigarcta tomentosa*. Hindwing.

The hind-wing (fig. 13) is pale brown with small hairs on the membrane and slightly longer hairs on the veins. As in the case of the fore-wing, there is in the nymphal wing pad a costal vein and trachea separated by a wide space from a group of three tracheae. The first of these tracheae precedes the sub-costa, and in the adult wing the corresponding vein is fused for its proximal half with the upper branch of the radial sector. Distally it lies close to the fore-border of the wing, but is not joined to the costal vein, being separated from it by the overfolded marginal wing-catch. The second branch of the radial sector meets the other branch close to the base of the wing; this feature and the fusion of M_2 and M_4 into a single vein are the principal characters in which the venation of the hind-wing differs from that of the fore-wing.

The Auditory and Sound-Producing Organs

There is no trace of auditory organs in either sex of *Tettigarcta*. In other cicadas the mirrors or auditory tympana are part of the first abdominal sternite and the auditory capsule part of the second tergite. The positions these organs would occupy if present are indicated in fig. 15. Myers records finding a slight swelling on the ventral lateral angle of the second tergite, but states that there is no external evidence that it is an auditory capsule. There is also no internal evidence on this point.

With respect to sound-producing organs, Tillyard (1926) mentions that the males have no vestiges of such organs, but Myers noticed that the 'first abdominal segment of *Tettigarcta* is greatly reduced and shows laterally a slightly swollen area, free from the long hairs that thickly clothe the rest of this region and furnished with faint ridges'. He continues 'Were not nearly all the other characters of *Tettigarcta* apparently highly primitive, one would be inclined to see in this structure the last vestiges of tymbals lost in the history of the race'.



Tettigarcta tomentosa

FIG. 14.—Lateral view of part of thorax and abdomen. mtn., metanotum; tmb., tymbal; a., abdominal segment. Other lettering as in previous figures.

FIG. 15.—Ventral view of part of metathorax and abdomen. pcx., postcoxale; pm., position of mirror; pac., position of auditory capsule. Other lettering as in previous figures.

Myers was correct in recognizing these swollen areas as tymbals. They lie on each side of the body in the position indicated in figs. 14, 15, and 16, and form part of the first abdominal tergite. Their surface is smooth and marked with a pattern of white stripes on a pale-brown background. The tymbals are not functional and the stripes are homologous with the ridges of fully-developed tymbals. A bundle of muscle fibres is attached directly to the inner surface of each tymbal. These muscles are attached ventrally to a narrow sclerotized plate that lies in the membrane of the first abdominal sternite. Tymbals are equally well developed in both sexes, but the tymbal muscles of the male are stronger than those of the female, though not so large as the huge tymbal muscles of other cicadas. The narrow transverse sclerotized plate from which the muscles arise is homologous with the abdominal furca of cicadas of various authors. Myers correctly stated that the furca was not an endoskeletal structure, but a differentiated anterior part of the first abdominal sternite. The first pair of abdominal spiracles lie close to the apices of this plate.

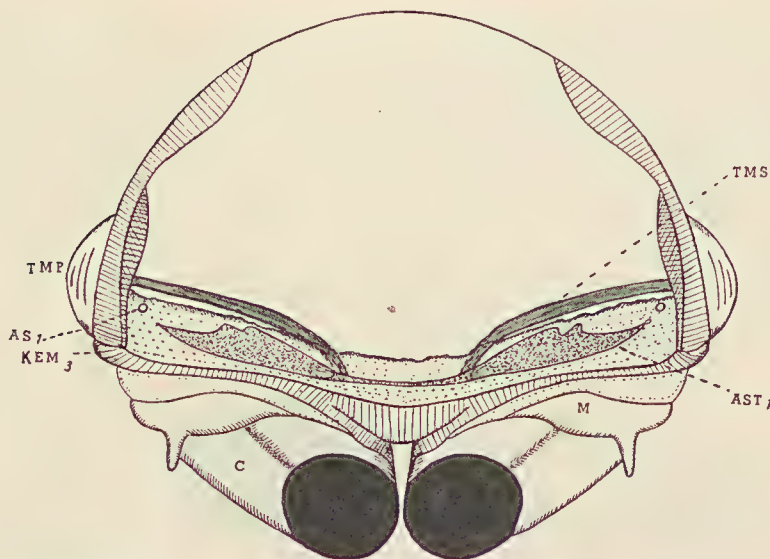


FIG. 16.—*Tettigarcta tomentosa*. Transverse view of part of metathorax and part of first abdominal sternite from behind. ast., sclerotized plate of first abdominal sternite.

The Alimentary Canal

The alimentary canal is illustrated in fig. 17. It resembles in essentials those of other cicadas as described by Myers. The filter chamber into which the oesophagus opens comprises the first ventricle of the stomach (Snodgrass, 1935), and part of the third ventricle, labelled 'mid-intestine' in the figure. The mesenteric sac is the second ventricle. In several fresh specimens of *Tettigarcta* that were examined, the mesenteric sac was found as a small, very wrinkled, and folded sac. In others, including some that had only recently abandoned their nymphal exuviae, it consisted of a thin smoothed-walled sac, distended with air, which occupied fully three-quarters of the abdominal cavity. The remaining quarter contained gonads and fat-body. Such a condition has also been recorded in leaf-hoppers (Evans, 1931).

The Tracheal System

The chief point of interest in the tracheal system lies in the alleged presence of a large tracheal air sac. Snodgrass is of the opinion that most of the abdominal cavity of the cicada *Magiccida septendecim* is occupied by a huge tracheal air chamber that opens directly to the exterior, through the first abdominal spiracles, and has tracheal tubes issuing from its walls. Myers claims that the sac is merely the distended mesenteric sac or second stomach ventricle of the alimentary canal. He was, however, able to trace a trachea from the first abdominal spiracle which, without penetrating the mesenteric sac, formed a tracheal knot on its surface from which tracheae ramified over the wall of the sac.

In *Tettigarcta* it is quite certain that there is no trace of any development of a tracheal air sac. In fig. 17 a trachea is shown which originates from the first abdominal spiracle of the right-hand side. This trachea breaks up into several smaller tracheae, but does not form a tracheal knot such as is described and illustrated by Myers. As, even in freshly-emerged cicadas, the mesenteric sac may fill the greater part of the body cavity, and must therefore become distended further in older insects in which fat-body is reduced, Myers' interpretation would appear to be

correct, in spite of the fact that Snodgrass (1935) gives a figure (fig. 237, p. 449) showing both the second ventricle of the stomach and an air sac in the same insect. The whole body cavity of *Tettigarcta* contains countless small air sacs, the mesenteric sac being especially well supplied with these, two of which are shown in the fig. 17.

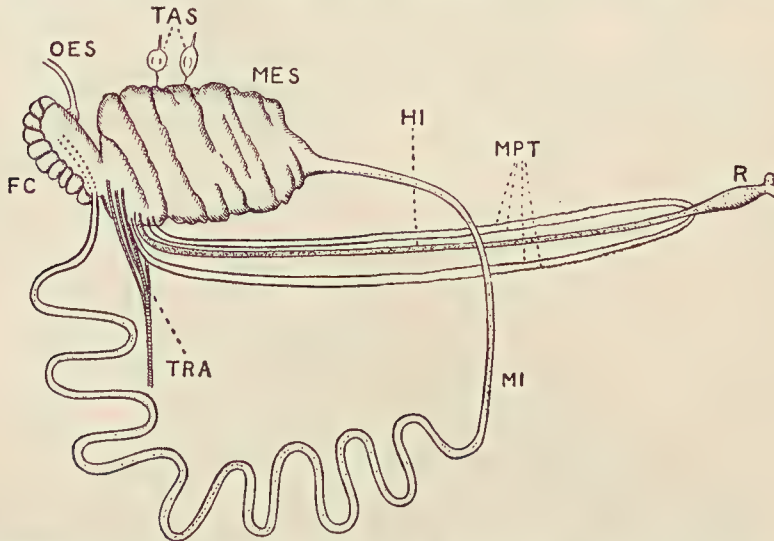


FIG. 17.—*Tettigarcta tomentosa*. Alimentary canal. fc., filter chamber; oes., oesophagus; mc., mid-intestine; hi., hind-intestine; mes., mesenteric sac; mpt., malpighian tubules; tra., trachea; tas., tracheal air sacs; r., rectum.

The anterior spiracles of the nymph are shown in figs. 6 and 7. The two large thoracic spiracles, which are closed by flaps, both occur in the mesothorax. There are eight abdominal spiracles. The two first of these have migrated forward, the anterior lying between the thorax and the segmented portion of the abdomen, the posterior just in front of the margin of the segment to which it belongs. Vogel (1923) believed that communicating longitudinal and transverse tracheae are absent in cicadas. This point has not been investigated, but Myers' statement 'that all the spiracles, without exception, are linked up by a longitudinal trunk on each side, is obvious from an examination of a nymphal exuviae' is open to question. Although superficial examination of a nymphal exuviae would certainly support this view, further investigation discloses that each trachea is distinct from its neighbour, and there is no trace of longitudinal trunks.

The Male Genitalia

The sternum of the eighth segment is produced posteriorly into a more or less flattened rectangular flap that underlies the ninth segment. The ninth segment is narrow dorsally and wide ventrally; from it arise the aedeagus, the prolongation of the fused basal plates and a pair of parameres (fig. 18). The aedeagus seen from above is trough-shaped, the trough forming a basin-like depression at its proximal end. The apex of the aedeagus consists of a fleshy pad with an outer border of large flattened wide-based spines, and an inner border of small inwardly-turned flat spines. Attached to the proximal end of this pad is a tongue-shaped process which serves to close the opening of the ejaculatory duct. The aedeagus is hinged basally with the basal plates; these plates are fused

together and produced into a boat-shaped structure that supports the aedeagus ventrally. The parameres, harpogones, or genital styles of the two sides are joined to each other by a set of transverse muscles, and have also other lateral muscles that are attached to the wall of the ninth segment. Lying immediately below the basal plates is a fleshy pad with an invaginated apodeme. Strong muscles that arise from this apodeme are joined to the posterior up-turned sides of the genital segment. The tenth segment is membranous and concave ventrally, and is separated into a pair of up-turned and in-turned flaps apically. The eleventh segment is ring-like and from it arises the anal segment.

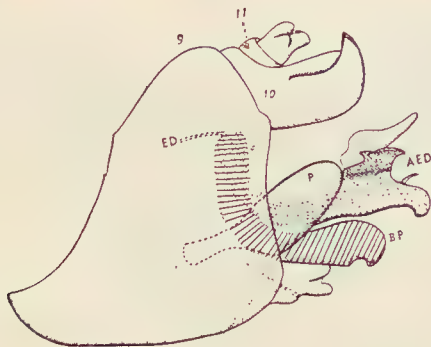


FIG. 18.—*Tettigarcta tomentosa*. Male genitalia. ed., ejaculatory duct; p., paramere; aed., aedeagus; bp., basal plates.

DISCUSSION

The present distribution of *Tettigarcta*, which is confined largely to high altitudes in south-eastern Australia and Tasmania, suggests that it forms one of the components of the cold-climate fauna that was dominant in these regions for periods both in mid and late Tertiary times. It is suggested that *Tettigarcta tomentosa* has retained a climatic rhythm which it acquired during a glacial epoch, since early winter temperatures that prevail between two and three thousand feet in Tasmania at the present day, may well be comparable to those that prevailed at sea-level during the short summer months of a period of intense cold. Further, it is believed that the habit of subterranean existence shared by the nymphs of all cicadas was originally developed as a response to cold climatic conditions.

Both species of *Tettigarcta* differ from all other recent cicadas in the following characters:

The nymphs have nine antennal segments, which is a greater number than that possessed by other cicadas.

The spiracles of the nymphs are not concealed by pleural flaps.

The adult is densely pilose and has an unusually small, narrow head in relation to the pronotum.

The pronotum has very large posterior and lateral expansions which conceal the scutum of the mesonotum.

The mesonotum has a well-developed scutellum that narrows apically and entirely conceals the metanotum.

The fore-wings are without cross-ridgings. The principal veins are evenly distributed and not massed against the fore-border.

The venation is remarkably complete and a nodal line is fully developed.

A separate costal vein is retained in the hind-wing.

The fore-femora are not markedly swollen, empodia are present, and all the legs are longer in relation to the body than is usual in the family.

Auditory organs are absent in both sexes.

Non-functional, but fully developed, sound-producing organs are present in both sexes.

The male genitalia have a true aedeagus, an unusual development of the basal plates, and harpogones are present.

It is proposed to discuss briefly the significance of only two of these characters, the sound organs and the nodal line. With regard to the sound organs, one can assume that the development of these was contemporaneous with, or slightly in advance of, the development of auditory organs. *Tettigarcta* has no trace of auditory organs in either sex, but has tymbals in both sexes, and only slightly less development of tymbal muscles in the female than in the male. Therefore one can reasonably conjecture that it is descended from an early cicadan stock that possessed in both sexes well-developed sound-producing organs and also sound-detecting organs. It is probable that neither set of organs was so complex or efficient as those found in present-day cicadas. For some reason, possibly associated with its nocturnal habits and cold climate environment, for modern cicadas are essentially sun-loving creatures, *Tettigarcta* ceased to be vocal. The sound-organs later lost their power to function and the auditory tympana, which were probably of a rudimentary nature reverted to undifferentiated parts of the segmental membrane of the first abdominal segment. It has been found that the membrane of this segment where it is adjacent to the break and curvature of the second abdominal sternite (fig. 15) is slightly denser than and of a different consistency from the rest of the segment.

Sound production in insects has arisen independently in many groups, and it can be assumed that in all instances it has commenced by simple methods, the actual organs involved never being specially designed for such a purpose. The rubbing of two adjacent parts of the thorax, or of legs together, or of legs against elytra, being the usual initial development. With cicadas, the position would appear to differ, as there is no rubbing action, but part of the dorsal surface of the first abdominal segment is differentiated into a complex tymbal, to which are attached strong tymbal muscles. If any evidence could be obtained to suggest that sound production was originally effected by the pull of certain muscles on to undifferentiated areas of the dorsal surface of the first abdominal segment, then the mystery of the origin of cicada song would be solved.

An examination has been made of the muscle system in the region of the base of the abdomen in *Eurymela fenestrata* Le P. & S.: This is a leaf-hopper, chosen on account of its large size and because preserved material was available. When the greater part of the abdominal segments is removed and the fat-body cleared away, the most noticeable structures are two very large columnar bands of muscles. These arise independently from near the mid-ventral line of a sclerotized ridge situated transversely in the membrane of the ventral surface of the first abdominal segment. These muscle bands are almost vertical, but directed somewhat laterally. They are attached dorsally to the hind margin of the metanotum. Each band is divided mid-way by a transverse circular sclerotized plate. The function of these muscles is unknown, but it needs no great flight of imagination to suppose that their dorsal attachments may have for some reason migrated for a short distance posteriorly. They would thus cease to be intersegmental muscles and become confined to the first abdominal segment. The membrane of this segment is strengthened dorso-laterally by two crescentic bars that form the hind margins of ovals. Part of the

hind border of the metanotum on each side bounds the ovals anteriorly. It is in a corresponding position to the membranous centres of these ovals that the tymbals of *Tettigarcta* are situated. One can conjecture that the gradual backward migration of the muscles resulted in a thickening of the abdominal wall, and that as a result of this thickening slight sound production became possible. The homologous muscles in *Eurymela* resemble much more, both in size and position, the tymbal muscles of modern male cicadas than those of *Tettigarcta*.

The significance of the nodal line has been fully discussed by Myers and earlier authors. It has already been pointed out that it consists of an irregular transverse line of weakness in the fore-wings of *Tettigarcta*. It is also developed to a varying, but less extent, in all other cicadas. Tillyard believed it to represent the beginnings of the division of the wing into a corium and membrane such as occurs in the Heteroptera. Imhof (1905) was of the opinion that it had some relation to the mechanics of flight.

The hemielytral condition of the fore-wings of Heteroptera is directly associated with the apical overlap of the fore-wings when they are at rest. No Homoptera, except certain Fulgoroids (Achilidae), have strongly overlapping fore-wings; they are either steeply tectiform or somewhat flattened, but distinct. The fact that the nodal line persists to such a degree in all cicadas, and that similar breaks in wings occurred in certain Mesozoic Homoptera,* would seem to favour Imhof's interpretation, especially as the wing is readily bent along the line in living specimens of *Tettigarcta*, more especially those that have only recently acquired fully-developed wings. It is further believed that the nodal line is only a parallel development with the condition that occurs in the Heteroptera and that it does not necessarily denote a common origin of the two groups or even a similar evolutionary trend.

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* e.g. *Pseudocossos zemczukovi* Martynov, Family Palaeontinidae, (Martynov, 1928).

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A New Genus of Mecoptera from Tasmania ⁽¹⁾

By

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(Communicated by J. W. Evans)

(Read 11th November, 1940)

PLATES VII, VIII

Late in 1939 Dr. J. W. Evans, of the Department of Agriculture, Tasmania, sent me for examination three specimens of a wingless Mecopteron from Mt. Wellington and Mt. Mawson, Tasmania. Since all three insects were females, publication of the description of the species was delayed, with the hope that the male also might be found. This hope was realized in September 1940, when Mr. D. Martin collected a male, as well as another female, on Mt. Mawson. These additional specimens were promptly sent to me by Dr. Evans. The insect turns out to be a very interesting one; it is not only the first record of the family Panorpidae (s.s.) in the Australian region, but it is also the only apterous member of the family known. I am greatly indebted to Dr. Evans for the opportunity of studying this remarkable species.

Apteropanorpa, new genus

Both sexes completely apterous, without indications of wing vestiges. Head large, much as in *Panorpa*, with a conspicuous rostrum, fully as large as that in *P. conigera* McL.; eyes small, only slightly protruding; ocelli absent; antennae elongate, with about 60 segments; clypeus broad, more remote from antennal insertions than in *Panorpa*; subgenal suture weak, subgenal processes very inconspicuous; labium long; mandibles toothed as in other Panorpids; maxillary palpi long, similar to those in *Panorpodes*; labial palpi small; thoracic nota contiguous, forming a heavy dorsal shield; 1st abdominal tergite fused with the metanotum; legs slender, typically panorpid, with smooth tarsal claws; abdomen very large and bulbous, with minute dorsal and ventral sclerites. *Female* abdomen: 9th abdominal sternite divided, forming two elongate plates, much as in *Panorpodes*; 10th abdominal sternite apparently absent (or very lightly sclerotized); 11th reduced to a small median plate; cerci long. There is apparently no internal skeleton (vulvar retractor apodeme) in the 9th abdominal segment. *Male* abdomen: tergites 2-6 small; tergites 7 and 8 coalesced with their sternites, forming a ring around the abdomen; 7th and 8th abdominal segments very short; 9th and 10th

(¹) Published under the auspices of the Tasmanian Biological Survey.

essentially as in *Panorpa*, forming a bulb which is curved over the 7th and 8th segments. The styles (forceps) ⁽²⁾ of the coxopodites of 9th segment are in the form of small, cylindrical processes directed inward and apparently attached to part of the 11th segment. The cerci absent or very minute.

Genotype: *Apteropanorpa tasmanica*, n.sp.

I consider this genus to be more closely related to *Panorpodes* (eastern Asia) than to *Panorpa* or *Neopanorpa*. This is especially well indicated by the structure of the terminal abdominal segments. In *Panorpa* the 9th abdominal sternite of the female is a large median plate, covering all of the ventral surface of the segment; in *Apteropanorpa* and *Panorpodes* the sternite is divided and reduced to a pair of slender plates. In *Panorpa* and *Neopanorpa* the 7th and 8th abdominal segments of the male are elongate, whereas in *Apteropanorpa* and *Panorpodes* they are very short. An even more striking similarity between *Apteropanorpa* and *Panorpodes* is found in the structure of the 6th abdominal segment of the male. In these genera the tergites and sternites of that segment are widely separated by membranous areas; but in *Panorpa* and *Neopanorpa* these tergites and sternites are fused so as to form a cylindrical plate around the entire segment.

The apterous condition of *Apteropanorpa* is the most obvious feature of the genus. The head is also unusual in having small eyes, no ocelli, and inconspicuous subgenal processes.

Apteropanorpa tasmanica, n.sp.

(Plates VII, VIII)

Length of body, not including antennae, 5.5-6 mm. Head reddish brown; antennae varying from dark brown to light reddish brown; thorax light yellow-brown above, dark reddish brown laterally; abdomen with dark reddish brown tergites, membranous areas mottled with brown and white; cerci brown. The coloration is essentially the same in all types, except one female paratype from Mt. Mawson, which has some dark brown on the mesonotum. The sternites of the terminal abdominal segments of the female probably include good specific characteristics; their structure is shown in Pl. VIII, fig. 4. The abdominal terminalia of the male are represented in Pl. VIII, figs. 1 and 2; the 9th sternite consists of a median plate, partially divided distally.

Holotype (♂): No. 25462, Museum of Comparative Zoology; collected on snow, on Mt. Mawson (4500 ft. elevation), Mt. Mawson, National Park, Tasmania, September, 1940 (D. Martin).

Allotype: collected on low shrubs (*Richea scoparia* Hook f.) on the summit on Mt. Wellington, Tasmania, May 31, 1939 (V. V. Hickman); in the Museum of Comparative Zoology.

Paratypes: 1 ♀, same collecting data as allotype; 1 ♀, Mt. Mawson (4200 ft. elevation), Tasmania, on snow (T. Raphael); both in the Australian Museum, Sydney.—1 ♀, same collecting data as holotype, in the Museum of Comparative Zoology.

⁽²⁾ For these abdominal structures I have used the terminology proposed by Ferris (Microentomology, 4 : 79-108, 1939).

In general appearance the female of this insect closely resembles the members of the family Boreidae, but the absence of the long ovipositor, a characteristic of the latter, eliminates all possibility of confusing it with a Boreid. Because of its wingless condition, determination of the family position of *A. tasmanica* must be made on details of body structure. The presence of the two tarsal claws as well as the structure of the abdominal terminalia excludes it from the Bittacidae; and the well-developed rostrum eliminates it from the Choristidae and Nannochoristidae. It has no characteristics, however, which prevent its inclusion in the family Panorpidae, though, of course, certain features, treated above as generic, have not previously been found in any panorpid. *Apteropanorpa* appears to be a highly specialized derivative of primitive Panorpid stock. It has some characteristics of *Panorpa* and some of *Panorpodes*. The elongate rostrum, for example, is like that of *Panorpa*, whereas the long maxillary palpi, simple claws, and the structure of the terminal abdominal segments are like those of Panorpodes. The wingless condition of *Apteropanorpa* is suggestive of *Brachypanorpa* (United States), the females of which are subapterous; but the rostrum in *Brachypanorpa* is even shorter than that of *Panorpodes*.

Apteropanorpa also presents a striking combination of general and specific characteristics. Among the former may be listed the nearly undivided 9th sternite; in all other Panorpidae this sternite is either forked or split for most of its length. On the other hand, the modification of the styles (forceps) of the coxopodite of the 9th abdominal segment of the male, and the absence of wings and ocelli are obvious specializations. *A. tasmanica* is especially interesting as a third instance of independent wing loss among Mecoptera, the other two cases being the Californian *Apterobittacus* (Bittacidae) and the Holarctic *Boreus* (Boreidae). Noteworthy in this connexion is the fact that three specimens of *tasmanica* were found on snow, an environment in which the adults of *Boreus* also normally occur.

As mentioned above, *tasmanica* is the first record of the family Panorpidae (s.s.) in the Australian region. Although this family is essentially a Holarctic one, many species have been found in southern India, French Indo-China, and the East Indies.⁽³⁾ The occurrence of a species of this family in the Australian region is therefore not very surprising; but what is remarkable is that this particular species is apterous, nivicolous, and confined (apparently) to certain mountains in Tasmania.

(3) Navas has described a Chilean Panorpid (*Panorpa ruizi*), but the collecting data of the unique type are probably incorrect (Rev. Chil. Hist. Nat. 30 : 330, 1926).

PLATE VII.

Apteropanorpa tasmanica, n.sp. (female, paratype).

FIG. 1.—Dorsal view.

FIG. 2.—Lateral view (only part of the antennae is shown in these photographs).

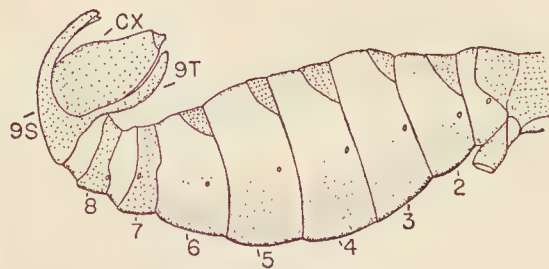


PLATE VIII.

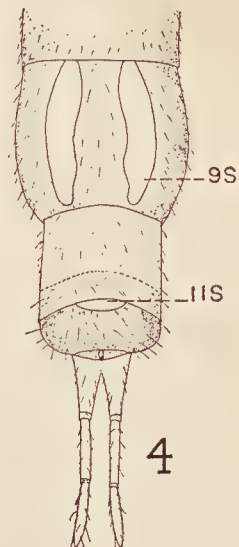
Apteropanorpa tasmanica, n.sp.

- FIG. 1.—Lateral view of abdomen of male (holotype). 2-8 abdominal segments; 9T, 9S, ninth abdominal tergite and sternite; cx., coxopodite of ninth abdominal segment.
FIG. 2.—Ventral view of male abdominal terminalia.
FIG. 3.—Front view of head of female.
FIG. 4.—Ventral view of terminal abdominal segments of female.
FIG. 5.—Lateral view of thorax of female. 11s., eleventh sternite; ABD., abdomen.

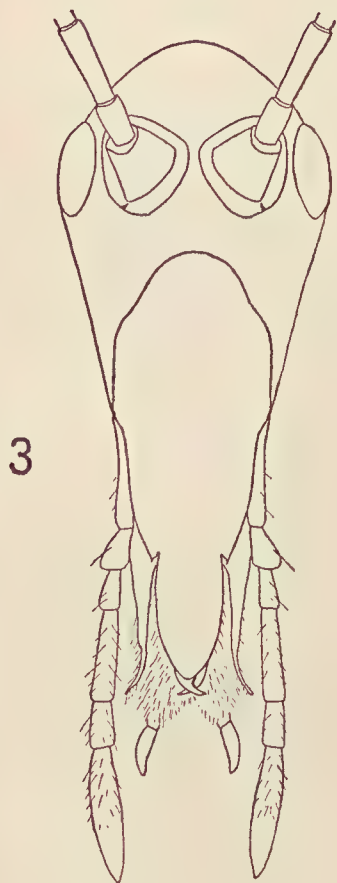
NATIONAL MUSEUM OF VICTORIA



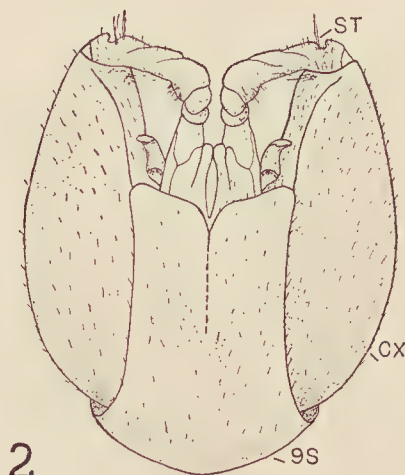
1



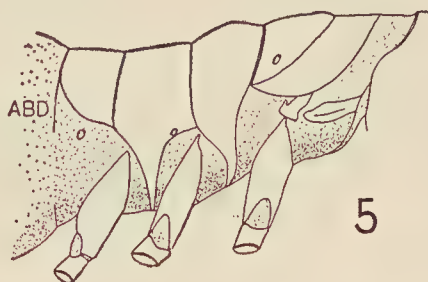
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3



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5

Observations on the Fishes of the Family Galaxiidae

Part III

By

E. O. G. SCOTT, B.Sc.

Director, Queen Victoria Museum, Launceston

(Read 11th November, 1940)

PLATE IX

The present paper records some general observations on *Galaxias* (*G.*) *truttaceus*, including the discovery of a regular sequence of colour-pattern phases in this species.

Conventions. All dimensions are recorded in millimetres: except in a few instances where ambiguity might arise, the unit of measurement is omitted. Length-classes are designated by their mid-points. Abbreviations used include: LS = standard length; LT = total length; h = width of class-interval; f with numerical suffix = frequency of length-class specified by suffix; $\bar{x}$ = arithmetic mean; Md = median; Mo = mode; Q_1 , Q_3 = 1st, 3rd, quartiles; σ = standard deviation, using $(n - 1)$.

Genus *Galaxias* Cuvier, 1817

Galaxias Cuvier, *Règn. Anim.* ed. 1. 11. 1817: 183. Haplotype *Esox truttaceus*

Cuvier, 1817

Galaxias (*Galaxias*) *truttaceus* (Cuvier, 1817)

Esox truttaceus Cuvier, *Règn. Anim.* ed. 1. 11. 1817: 184.

Galaxias ocellatus McCoy, *Intercol. Exhib. Ess.* 7. 1866: 14.

Galaxias truttaceus Regan, *Proc. Zool. Soc. London.* 1905 (1906). II.: 378: pl. XII. fig. 4 (references).

MATERIAL AND LOCALITIES

Material examined, comprising upwards of 700 specimens, representing 36 Tasmanian and several extralimital localities, falls conveniently into 5 sections noted below. Letters in brackets refer to map (Text-fig. 1): in series marked with an asterisk *G. (G.) truttaceus* occurs in association with *G. (G.) attenuatus* (Jenyns, 1842).

(i) *Punchbowl Creek, Launceston* (A). 23 series. Series 89*, 8/10/35; 90*, 10/11/35; 91*, 24/11/35; 92*, 15/12/35; 115*, 18/10/36; 117*, 22/11/36; 119*, 31/12/36; 124*, 31/1/37; 125*, 126*, 14/2/37; 129*, 21/3/37; 145*, 24/10/38; 146*, 19/11/38; 151*, 31/12/38; 153, 8/1/39 (E. Chugg); 156*, 29/1/39; 157*, 26/2/39; 158*, 19/3/39; 159*, 26/3/39; 166*, 27/5/39; 167*, 28/5/39; 171*, 16/3/40; 172*, 30/9/40.

(ii) *Other Tasmanian Localities* (B-Z; a-b; d-k). 59 series. Series 1, no locality, no date (Museum coll.); 4*, Kelso (B), 22/12/33 (R. Slater); 5, Cormiston (C), April 1933 (E. Lumley); 6, Racecourse Creek, Launceston (D), no date (W. Smith); 7, 16, 77*, 87, 105, Saltwater Creek, Low Head (E), April 1933, 19/3/34, 24/4/35, 6/9/35, 24/7/34 (G. Green); 9, Cook's Creek, Adventure Bay, Bruny Island (F), 24/1/34 (V. V. Hickman); 10, 19, 35, 78, various creeks, northern end of Great Lake (G), 8/2/34, 29/3/34, 3/6/34, 1/5/35 (10 N. J. B. Plomley, 78 R. Wigram); 12, Sulphur Creek (H), 15/2/34 (N. Gill); 17*, 34, 43*, 49, 52*, 53*, Cox's Creek, Wynyard (I), 29/3/34, 29/5/34, 24/11/34, 11/12/34, 27/12/34, 27/12/34 (17, 34, 43*, 53 J. Harrison); 18, North Esk at St. Leonards (J), 29/3/34 (A. L. Meston); 24, 65, 66, 96, 97, 130, 154, 169, creeks, drains, lake itself, Great Lake, western shore, near, and south of, Reynold's Neck (K), 2/4/34, 18/2/35, 19/2/35, 27/1/36, 27/1/36, 4/4/37, 23/1/39, 12/2/40 (96, 97, 130, 154 D. Paton, 169 A. Pike); 25, River Brid (L), 4/4/34 (A. L. Meston); 28*, Franklin (M), 26/4/34 (A. B. Gaul); 30, 60 Pyengana (N), 12/5/34, 6/2/35 (30 E. Hookway, 60 H. Le Fevre); 33, Carroll's Creek, Rocky Cape (O), 21/5/34 (A. L. Meston); 38*, 39*, 40*, River Tamar (P), 17/9/34 (whitebait); 41*, Upper Scamander (Q), 18/10/34 (A. E. Elms); 54*, Clayton Rivulet (R), 31/12/34; 71, Tonganah (S), 13/3/35 (K. E. Jackson); 72*, creeks running into Don River (T), 14/3/35 (A. Smith); 86*, creek at Spreyton (U), 1/9/35; 88, creek running into River Pieman (V), 8/3/35 (M. White); 93*, Young Town (W), 28/12/35 (R. Gardam); 95*, creek about 4 miles south of Sorell, West Coast (X), 2/1/36 (A. L. Meston); 99, Snug River (Y), 16/1/36 (P. B. Edwards); 100*, Sassafras Creek, at Pardoe Beach (Z), 17/1/36 (A. L. Meston); 108*, Latrobe (a), 14/9/35 (whitebait); 109*, Big Eel Creek, near Temma (b), 6/2/36 (S. L. Larnach); 110*, Mella (d), 17/4/36 (B. Burnley); 116*, Pedder River (e), 22/1/36 (S. L. Larnach); 118*, Stony Creek, near Swansea (f), 2/12/36 (G. C. McKinlay); 120*, River Pieman, at mouth (g), 23/1/37 (A. L. Meston); 121, River Pieman, at Corinna (h), 23/1/37 (A. L. Meston); 122, Middleton's Creek (i), 24/1/37 (A. L. Meston); 140*, Welcome River (j), 7/1/37 (A. L. Meston); 161*, 163*, Mowbray, Launceston (k), 1/4/39, 17/4/39 (F. Frankcombe).

(iii) *Islands of Bass Strait; Victoria*. (These localities not included in map, Text-fig. 1). 5 series. Series 32, Currie, King Island, 19/5/34 (M. C. Challis); 59, 69, Clarke Island, 30/1/35, 9/3/35 (A. MacLaine); 68, Yarra River, Abbotsford, Victoria; Lilypilly Gully, National Park, Victoria; creek near Timboon, Victoria; Marat Creek, Pakenham, Victoria (exchange, National Museum, Melbourne); 164, Rhodes' Creek, western side of Mt. Strzelecki, Flinders Island, 16/1/38 (C. Davis).

(iv) *Tank Series*. Numerous specimens from various localities (most important, Punchbowl Creek, Launceston, and Great Lake) have been kept alive in observation tanks over a period of about five years.

(v) *Overseas Museums Material*. Material in the collection of the National Museum, Melbourne; Australian Museum, Sydney; British Museum (Natural History), London; Muséum National d'Histoire Naturelle, Paris; Museum für Naturkunde, Berlin; and a number of Museums in U.S.A. has also been examined.

DISTRIBUTION: ABUNDANCE

(a) *General*. Tasmania, including Bruny Island (Series 9), King Island (Johnston, 1888; Series 32), Clarke Island (Scott, 1936a; Series 59, 69), Flinders Island (Series 164), Victoria. McCulloch (1915) incidentally mentions South Australia: this State is not included in the Check-list (McCulloch, 1929), and I can find no other published record for it. The British Museum (Natural History) has seven specimens, of which there appears to be no published account, labelled

'New South Wales: Stead'. Not known from New Zealand: it has been shown (Scott, 1936*a*) that the designation by McCulloch (1929, p. 48) of New Zealand as type-locality is an error.

(b) *Tasmania*. Most rivers and streams (Text-fig. 1); common in Great Lake. No authentic data available regarding far South-West, or Lake St. Clair. Not included in upwards of 200 Galaxiids examined from Cradle Valley district.

(c) *Abundance*. In Tasmania *G. (G.) truttaceus* ranks next in abundance to *G. (G.) attenuatus*. Mack (1936) has noted it occupies a similar position in Victoria.



FIG. 1.—Sketch map of Tasmanian localities of material examined. For reference-letters see text.

SALINITY TOLERANCE

(a) *Salinity Tolerance*. All information available in the literature would indicate that in Tasmania *G. (G.) truttaceus* is confined to the Central Plateau, and fresh water of inland creeks and upper reaches of rivers. Thus Johnston (1883, p. 130) observes 'Abundant in most of our freshwater streams, but not descending to brackish water like *G. attenuatus*'; and Lord and Scott (1924, p. 23) expressly state it 'does not occur in the lower reaches and brackish estuaries,

where its place is taken by the 'Jollytail' [*i.e.*, *G. (G.) attenuatus*]. Actually, I find, *G. (G.) truttaceus* descends right to the beach-line: indeed, some observations made at Stanley in October, 1935, though unverified by the actual collection of material, strongly suggest it may upon occasion enter the sea on the falling tide.

Records from salt or highly brackish water include: Kelso (Series 4); Salt-water Creek, Low Head (7, 16, 77*, 87, 105); Sulphur Creek, about 300 yards from the sea (12); Upper Scamander (41*); Clayton Rivulet, below railway, at upper limit of beach (54*); brackish creek, Clarke Island, Bass Strait, 200-300 yards from sea (69); Sassafras Creek, Pardoe Beach, close to mouth, at a point to which the high tide backs up (100*); mouth of River Pieman (120*): (asterisk indicates presence in sample of *G. (G.) attenuatus*).

In several cases the available material affords information regarding the occurrence of the fish at widely separated points in the same waterway. Thus Series 120, 121, 122, collected within two days, provide examples from mouth of River Pieman (associated with *G. (G.) attenuatus*); the Pieman at Corinna (about 14 miles from sea by water), where water is still tidal, somewhat brackish; and from Middleton's Creek (fresh water), a tributary of the Savage, itself a tributary of the Pieman, into which it empties a mile or so below Corinna: further, Series 88 provides specimens from a creek draining into the Pieman some 7 miles from the coast. Again, in the River Tamar, samples are available from several localities between the mouth and Launceston, some forty miles inland; and, further *G. (G.) truttaceus* is traceable along lengthy stretches of the North Esk and South Esk, by whose confluence the Tamar is formed.

(b) *Salinity Gradient*. With the abandonment of the conception, hitherto held, that *G. (G.) truttaceus* and *G. (G.) attenuatus* are essentially inland and coastal species, respectively, overlapping and mingling in an intermediate region lying between the upper limits of tidal influence and the foot of the Central Plateau, the question naturally arises as to whether, in Tasmania, the former species exhibits any marked salinity gradient at all. Data bearing on this problem is set out in Table I.

TABLE I

G. (G.) TRUTTACEUS - G. (G.) ATTENUATUS: FREQUENCY RATIO IN WATERS OF VARYING SALINITY

Salinity-category	No. of Localities	No. of Series	Number of Specimens				
			<i>G. (G.) truttaceus</i>	<i>G. (G.) attenuatus</i>	Total	Average No. in Sample	<i>G. (G.) truttaceus</i> %
Salt or highly brackish	5	5	45	60	105	21	42.9
Moderately brackish	3	6	28	117	145	24	19.3
Fresh {	(a) Punchbowl Creek	1	202	640	842	44	24.0
	(b) Other Localities	9	24	90	114	23	21.1
	(c) Total	10	226	730	956	35	25.2

An analysis of samples (16 localities, 20 series, 192 specimens) of *G. (G.) truttaceus* from localities in which *G. (G.) attenuatus* occurs (e.g., Great Lake series excluded), but unassociated, as collected, with that species, yields the following additional data: salt or highly brackish water, 2 localities, 3 series, 39 specimens, average number per sample 13; moderately brackish water, 6, 8, 73, 9; fresh water, 8, 9, 80, 9.

While the information recorded in Table I, not being based on material collected expressly in relation to the present problem (note, e.g., disregard of seasons, possible tendency of some collectors to concentrate on one particular species, &c.), does not provide rigorously random sampling on which to base a proper quantitative analysis (e.g., a satisfactory computation of Forbes' coefficient of association), nevertheless, it does appear generally decidedly unfavourable to an assumption of an inverse correlation in this species between frequency and salinity.

(c) *Experimental Evidence.* That *G. (G.) truttaceus* behaves, under laboratory conditions, as a euryhaline form has been demonstrated by a number of experiments in which fish have been brought from fresh to (artificial) sea-water—average analysis of Dittmar (1884)—and *vice versa*, without suffering any serious disturbance of metabolism, or exhibiting any marked changes of behaviour, other than temporarily enhanced general liveliness and quickened respiratory rhythm on being subjected to an abrupt increase in salinity. These trials have varied in severity from, on the one hand, starting with tap-water, a regular increase in salinity of 3.5 gm per 1000 gm on each of 10 successive days, to, on the other hand, direct transference from tap-water to sea-water of salinity 35 gm per 1000 gm: in no instance has the fish manifested any noteworthy symptom of distress.

ASSOCIATION WITH *G. (G.) ATTENUATUS*

(i) *General.* That *G. (G.) truttaceus* forms a conspecies with *G. (G.) attenuatus* over the whole ecological range of the latter species is sufficiently established by the facts recorded above. In many localities the two species are found occupying the same pool: in captivity they share a tank in complete community.

(ii) *Whitebait.* It has been shown (Scott, 1936b) that young individuals of *G. (G.) truttaceus* and *G. (G.) attenuatus* form a minor constituent of Tasmanian 'whitebait', in which they are associated with the haplochitonid *Lovettia sealii* (Johnston)—the 'whitebait' of New Zealand largely consists (Clarke, 1899; Phillipps, 1919) of *inanga*, or *G. (G.) attenuatus* fry. Schools of whitebait, often comprising an almost incredible number of individuals, appear in Northern Tasmanian rivers and in the Derwent in Spring.

It is generally accepted that the Galaxiidae are a group of Salmonoids of marine origin, related to the Osmeridae (Regan, 1906, 1913), which, like the Northern circumpolar Salmonidae, are establishing themselves in fresh water; and it is well established (Hutton, 1896; Clarke, 1899; Best, 1903; Whitely, 1935) that in New Zealand *G. (G.) attenuatus* descends to the sea periodically to spawn. The presence of *G. (G.) truttaceus*, as fry, in whitebait, and observations on its occurrence in Punchbowl Creek noted below suggest that this species is not improbably facultatively catadromous, and that, when not confined in landlocked waters, it may retain the presumably primitive spawning habit of the family.

(iii) *Punchbowl Creek.* In Punchbowl Creek, Launceston, *G. (G.) truttaceus* and *G. (G.) attenuatus* commonly occur together, with the latter species present in greater abundance. It is, however, worthy of note that over the period 6/2/34-7/10/35 the whole catch of 12 series, comprising 310 specimens, from this locality consisted exclusively of *G. (G.) attenuatus*. While experience has shown that *G.*

(*G.*) *truttaceus*, except when young, is more wary of the trap employed in these investigations (for description, see Scott, 1938, p. 116)—with adult fish, it is quite customary, in a pool containing, say, twenty *G. (G.) attenuatus* and ten *G. (G.) truttaceus*, to trap fifteen of the former species without securing one specimen of the latter—it seems probable these results are to be interpreted as indicative of the failure in 1934 of the normal vernal immigration of *G. (G.) truttaceus* discussed below. In Punchbowl Creek the great majority of specimens, apart from fry, are only of moderate size (LS 60-75): large individuals are unusual, but I have measured examples up to LS 150.

ASSOCIATION WITH OTHER GALAXIIDS

In Tasmania *G. (G.) truttaceus* probably occurs associated with all our local Galaxiidae. Its association with the following species has been established: *G. (G.) attenuatus* (*vide supra*), *G. (G.) auratus* (Great Lake, *vide* Johnston), *G. (G.) parkeri* (Great Lake, Snug River), *G. (G.) scopus* (Clarke Island, Bass Strait, in same series as holotype): it is recorded from the type-locality of *G. (G.) weedoni* (River Mersey), *Saxilaga (S.) anguilliformis* (Cox's Creek, Wynyard). I have no authentic records of it in association with *Paragalaxias shannonensis* (known only from type-locality, Shannon River), *Saxilaga (S.) cleaveri* (based on unique holotype, found in eucalyptus stump, West Ulverstone), *G. (G.) johnstoni* (known only from four specimens, creek, near Nive River), *G. (G.) affinis* (type-locality Lake St. Clair): further investigations will, however, probably establish it as an associate of these four forms.

VERNAL JUVENILE MIGRATION

(a) *General.* The occurrence of *G. (G.) truttaceus* in whitebait, and the appearance of fry in Punchbowl Creek have already been noted: the latter migration is discussed below.

(b) *Periodicity.* Series taken in Punchbowl Creek between February, 1934 and October, 1935 contained no specimens. In the early part of the summer of 1935-6, however, with the immigration into the Creek of *G. (G.) attenuatus* fry (this migration has been studied in a previous paper; Scott, 1938), there came also an invasion of juvenile *G. (G.) truttaceus*, which penetrated in large numbers into the second, or *Larnoo*, section (for ecological divisions of Creek see Scott, 1938, p. 116, footnote), and, in diminished numbers, to the upper limit of the third. Analysis of the four series 89-92, 8th October - 15th December, 1935, *Larnoo* section, shows that of 51, 17, 73, 88 specimens of mixed *G. (G.) attenuatus* and *G. (G.) truttaceus* 18, 7, 18, 38, an average of 35%, were the latter species: the great majority were juvenile (only exceptions, 2 specimens of Series 89, of LT. 68.5, 87.0). Further observations in this section were rendered impracticable by the sudden and almost complete drying-up of the Creek, resulting in a heavy mortality, in which *G. (G.) truttaceus* suffered proportionally much more severely than *G. (G.) attenuatus*, a score or more individuals often being found lying in a square yard on the bed of a dried-up pool in which the failure of the stream had trapped them.

Samples from the *Larnoo* section on 27th September, 1936 (Series 113) and 4th October (Series 114) consisted exclusively of large examples of *G. (G.) attenuatus*, and an inspection made on 11th October showed that the juvenile immigration for the year still had not then begun, the influx taking place between the last-mentioned date and 18th October. *G. (G.) truttaceus* was present this year in decidedly smaller proportion than in the preceding year, Series 115, 117,

119 (October, November, December, 1936) consisting of 69, 83, 20 specimens, of which 4, 4, 4 were *G. (G.) truttaceus*, an average of 7%. This percentage was virtually maintained during the first quarter of the next year, Series 124-126, 129, taken between 31st January and 21st March, 1937, comprising in all 156 specimens, of which 9 were *G. (G.) truttaceus*.

No observations were made in the spring of 1937. In 1938 the immigration had occurred by 24th October, a sample on that date containing 18 *G. (G.) attenuatus* and 11 *G. (G.) truttaceus*. Series 146, 151, taken in November and December, contained 11 (20%) and 8 (17%) of *G. (G.) truttaceus*, an average for the last three months of 1938 of 23%. Five samples in the first five months of 1939 consisted of 143 fish, of which 13 (9%) were *G. (G.) truttaceus*.

The vernal immigration of 1939 was not recorded. A sample of upwards of 50 fish on 30th September, 1940 (Series 172) included 2 early arrivals of the 1940 class of *G. (G.) attenuatus*: a week later, the main body had arrived, a sample of 47 from the *Queechy* section containing 37 juveniles. This year the *G. (G.) truttaceus* element was small, Series 172 including only a few specimens, Series 173 none.

It is thus established that there commonly occurs in Punchbowl Creek an extensive immigration of juvenile *G. (G.) truttaceus*, in company with *G. (G.) attenuatus* fry, the main body of fish arriving in late September-early October. A possible secondary invasion in February-March is noted below.

(b) *Metrical Characters*. The standard length of 10 samples (trapped) of juvenile *G. (G.) truttaceus* population in Punchbowl Creek in October-December 1935, 1936, 1938 is specified in Table II.

Table II shows the vernal immigrant population is essentially a juvenile one, having $\bar{x}_{LS}$ about 47, and modal LS-class 45.5 ($h = 1$).

The data afford no clear evidence regarding growth during the three months under review. It is possible secondary minor waves of invasion may occur, especially since frequency polygons for *G. (G.) attenuatus* in Punchbowl Creek exhibit (Scott, 1938) a primary mode in LS-class 45 ($h = 10$), and a secondary mode in LS-class 35 ($h = 10$), apparently indicative of a second juvenile invasion of that species in February-March. In this connexion, analysis of LS specifications of samples collected in the early months of the year (not included in Table II) yields two noteworthy facts: first, in 1937 (no data for 1936) the smallest specimen of *G. (G.) truttaceus* secured in these investigations (LS 37.8) was obtained on 14th February, $\bar{x}_{LS}$ of the whole sample taken on that date being 40.2, decidedly less than $\bar{x}_{LS}$ for samples (Series 124, 129) in January and March; secondly, in 1939 (no data for 1938) a sample (Series 158) in March (one specimen only) had LS 46.5, compared with $\bar{x}_{LS}$ 50.4, 53.7, 56.0, 48.9 for samples (Series 156, 157, 166, 167) collected in January, February, May (2 samples in May).

With $h = 1$, LS distribution of the 130 specimens in Table II is; ($f_{41.5}$) - ($f_{57.2}$) = 6, 7, 10, 13, 19, 15, 10, 10, 11, 8, 8, 2, 2, 4, 2, 1, 2.

(c) *Non-Metrical Characters*. On arrival in Punchbowl Creek, some individuals still exhibit a furrow with double raised flanking walls locating the region of absorption of the yolk-sac, and, slightly dorsad of this depression, a subspherical vascular plexus, clearly visible through the transparent body-wall as a red spot.

Pigmentation is little developed. In 1935, October specimens exhibited Colour-Phase A (see *Colour-Phases*, below); on 11th November 5 out of 7 had advanced to middle and late subphases of Phase B; on 24th November a sample of 18 included

TABLE II
 GALAXIAS (G.) TRUTTACEUS: STANDARD LENGTH SPECIFICATION OF JUVENILE POPULATION IMMIGRANT INTO PUNCHBOWL CREEK,
 LAUNCESTON, OCTOBER, NOVEMBER, DECEMBER, 1935, 1936, 1938

Year	Series No.	No. of Specimens	Min.	Max.	$\bar{x}$	Mode ⁽¹⁾	Q	Md	Q ₃	σ
1935	89	8/10/35	45.0	57.5	46.99	46.5 [4]	44.7	46.2	48.6	4.21
	90	10/11/35	43.8	54.5	48.97	 ⁽³⁾	46.0	49.0	51.0	3.46
	91	24/11/35	43.0	55.1	48.38	45.5 [3]	45.5	47.7	51.4	4.26
	92	15/12/35	41.2	57.7	45.29	44.5 [7]	43.1	44.7	46.4	3.33
Totals and Means, 1935	4 Series	8/10/35-15/12/35	41.2	57.7	46.66	 ⁽⁴⁾	44.0	45.8	49.0	4.12
1936	115	18/10/36	45.6	51.6	47.95	47.5 [2]	46.3	47.8	49.6	2.57
	117	22/11/36	46.1	53.8	49.28	46.5 [2]	46.4	48.8	52.1	2.56
	119	31/12/36	48.8	51.6	50.23	 ⁽³⁾	49.4	50.3	51.1	1.61
Totals and Means, 1936	3 Series	18/10/36-31/12/36	45.6	53.8	49.15	 ⁽⁵⁾	46.9	49.9	51.1	2.57
1938	145	24/10/38	45.7	52.8	49.27	48.5 [3]	47.8	48.6	51.1	2.31
	146	19/11/38	42.2	55.8	45.95	45.5 [6]	44.0	45.2	46.8	3.16
	151	31/12/38	42.4	56.0	49.00	48.5 [2]	46.9	49.0	51.0	4.37
Totals and Means, 1938	3 Series	24/10/38-31/12/38	42.2	56.0	47.51	45.5 [3]	45.0	47.1	50.0	3.44
Totals and Means, 1935, 1936, 1938	10 Series	Oct.-Dec., 1935-6-8	41.2	57.7	47.15	45.5 [19]	44.6	46.4	49.4	3.71

⁽¹⁾ Mode with $h = 1$; figures in brackets denote number of cases.

⁽²⁾ Two specimens of LS 61.2, 75.5, clearly belonging to previous year-class, omitted from Table.

⁽³⁾ With $h = 1$, no mode.

⁽⁴⁾ With $h = 1$, plurimodal: 44.5, 45.5, 46.5 classes each with 10 cases.

⁽⁵⁾ With $h = 1$, plurimodal: 46.5, 47.5, 50.5, 51.5 classes each with 2 cases.

several individuals in Interphase B C. In 1936-7, October arrivals were in Phase A, reaching B by late November, Interphase BC in January and February, and Phase C in March. In 1938, 10 of 11 specimens taken on 24th October were in Interphase AB, one individual being in subphase Bd; of 20 fish on 19th November, 17 were in late, 1 in middle, 1 in early Phase B, while one individual had arrived at Phase C. Samples of the 1938 class collected in January, February, March, 1939 were in Phase B, Interphase B C, Phase C: of 9 specimens in May (Series 166, 167 pooled) 1 was in advanced Interphase B C, the rest in Phase C.

VARIATION OF COLOUR-PATTERN WITH GROWTH: COLOUR VARIETIES

(a) **General.** Our knowledge of colour-pattern in the Galaxiidae is scanty. Of possible differences associated with sex, season, locality we know virtually, or literally, nothing: of individual variation as much as, but no more than, the systematist records in the compilation of his specific diagnoses. Colour-varieties in *G. (G.) truttaceus*, long known, are discussed in subsection (d) below. In a previous paper (Scott, 1936a, p. 94) some tentative associations of colour-pattern types (spots, bars, blotches) with other diagnostic features have been made in the characterization of what appear to be species-groups. Variations of colour-pattern with age have been the subject of references, more or less incidental in character, by Clarke (1899), *G. (G.) kokopu*; Regan (1906), *G. (G.) lynx*, *G. (G.) weedoni* (Lake Laura specimens); McCulloch (1915), *G. (G.) attenuatus*; Eigenmann (1924), *G. (G.) maculatus*, *G. (G.) globiceps*; Scott (1936a), *G. (G.) parkeri*; Whitley and Phillipps (1939) *G. (G.) argenteus*: in general, these observations have been concerned with a progressive increase in extent, and at times in complexity, of pigment-deposition (Clarke, however, notes markings on body of *G. (G.) kokopu* are relatively larger in young).

Though the genotype of *Galaxias* has now been known to science for nearly a century and a quarter, the fact that it manifests a regular sequence of changes in colour-pattern appears hitherto entirely to have escaped notice. So far as I can ascertain, references in the literature to colour-markings on the body of this species are consistently confined to mention of the annulated dark spots regularly, and the dark post-pectoral bar or bars usually, present in the adult—e.g., “readily recognized by the trout-like black spots on the sides of the body” (Mack, 1936): note, also, McCoy’s (1866) significant synonymic specific name *ocellatus*. The present investigations show that *G. (G.) truttaceus* exhibits a series of successive colour-pattern phases almost as marked as, and presenting at least a superficial resemblance to, that encountered in certain Salmonidae.

My attention was first drawn to this circumstance by the receipt, in March, 1934, of specimens of what, judged from the colour-pattern alone, would naturally be taken for an undescribed species. Subsequent investigation revealed the presence of a strikingly barred, wholly unspotted phase of *G. (G.) truttaceus* in Punchbowl Creek: the complete pattern-sequence has since been thoroughly established by systematic collecting in this locality, supplemented by the keeping of this species under observation in fish-tanks continuously over a period of several years.

(b) **Colour-Phases.** Three phases, two interphases, and about ten subphases may be recognized. While clearly chronologically successive, the subphases manifest some overlapping (particularly in samples from different localities, and, to some extent, in different year-classes) when regarded as a direct function of size, LS min. of one phase in one series being sometimes exceeded by LS max. of preceding phase in another sample: cf. observations by Eigenmann (1924, p. 50) on

variation in duration of retention of unspotted juvenile condition in *G. (G.) maculatus*. Marked differences in bodily proportion (subsection (c)) characterize the primary phases. The following analysis, based primarily on Punchbowl Creek material, is confined to macroscopic features: microscopic aspects of the changes involved are of interest, and worthy of detailed study.

Phase A: Unornamented Stage. (The term 'unornamented', not strictly accurate, conveniently connotes complete absence of body-bars and large spots consistently present in succeeding phases). In very young, presumably immediately post-larval specimens (Plate IX, Fig. 2) the body is transparent: ornamentation is confined to the caudal fin, and comprises, first, a highly characteristic vertical dark, almost black basal bar, commonly about $\frac{1}{2}$ - $\frac{3}{4}$ eye-diameter in width; secondly, a series of 6-10 proconcave dark arcs covering most of the fin (often better developed at a somewhat later stage). In whitebait samples the caudal bar may be in two (united) halves, each with a convex posterior margin.

The pre-pigmentation stage in Galaxiids has been recorded for *G. (G.) maculatus* by Eigenmann (1924): for *G. (G.) attenuatus* by McCulloch (1915), Scott (1938); see also speculation by Regan (1906) as to the possibility of *G. (G.) gracillimus* being a larval form of this species. The presence in very young *G. (G.) truttaceus* of a patterned caudal fin lends support to a suggestion (Scott, 1938, p. 121) that this feature may well be a primitive family character, enjoying brief ontogenetic manifestation. It should be noted that the extensive proximal caudal bar of *G. (G.) truttaceus* is entirely absent in *G. (G.) attentuatus*.

Individuals in Phase A occur among whitebait, and in recently arrived vernal influxes in Punchbowl Creek. They are commonly of $LS\ 43 \pm 5$, but unornamented individuals of $LS > 52$ occasionally occur.

Interphase AB: Preliminary Pigmentation Stage. The interesting early stages of somatic pigmentation are predominantly microscopic; macroscopically they result in a slight decrease in transparency (especially above mediolateral line), quite evident in preserved material, barely noticeable in life; and in the first pigmentary outlining of the myomeres. Basal caudal bar conspicuous; caudal arc-pattern usually most apparent in this stage (Fig. 3). Punchbowl Creek examples have been taken in late October.

Phase B: Barred Stage. In the course of this stage the young fish gradually develops a series of forwardly directed chevrons or subvertical bars (angulation frequently markedly more acute posteriorly) that lend it an appearance strikingly at variance with that of the adult. Bars, which are most prominent in Cox's Creek specimens (Fig. 16), commonly number 12-15: on the average, in Punchbowl Creek and Cox's Creek material bars are rather narrower than, in Great Lake specimens about one-half as wide as, their interspaces.

The normal schedule of bar-development appears to be as follows. *Subphase Ba* (Fig. 4): upper halves only of chevrons extending progressively from head to level of pelvic origin. *Subphase Bb* (Fig. 5): the same, continued to level of vent. *Subphase Bc* (Fig. 6): head-pelvic interspace with chevrons complete; pelvic-anal interspace with half-bars above mediolateral line; postanal region bare. *Subphase Bd* (Fig. 7): chevrons complete to level of base of anal fin; postanal region bare. *Subphase Be* (Fig. 8): upper halves of bars now developed on caudal peduncle. *Subphase Bf* (Fig. 9): complete series of chevrons or bars from behind head to base of caudal.

Occasional departures from the normal programme include: (i) appearance of two or three full chevrons prior to complete development of superolateral series of half-bars (Fig. 17); (ii) omission of Subphase Be, with Bd passing directly

into Bf. In general, however, the sequence follows a well-marked course involving, first, the preanal region, with progressive development caudad of half-bars, then of complete bars; secondly, the postanal region, with similar succession.

Basal caudal bar now less conspicuous; caudal fin pattern normally almost, or wholly, lost; blackish oblique suborbital streak and dark upper labial marking, characteristic specific characters of adult *G. (G.) truttaceus*, begin to appear.

Fish exhibiting Colour-Phase B are commonly of LS 45 ± 3 , with recorded extremes of 37.8 and 56.7 (Punchbowl Creek); 50 ± 4 (Cox's Creek); 45 ± 3 (Great Lake). Punchbowl Creek individuals normally exhibit this colour-stage in November (exceptionally, as early as late October, as late as January); Cox's Creek specimens were taken in March, November, December; examples are included in Great Lake series collected in January, March.

Interphase BC: Barred-Spotted Stage. Shortly after establishment of Subphase Bf, there sets in a progress of disintegration of chevrons and bars into subvertical linear series of spots. This process proceeds in the reverse direction from bar-formation, becoming initiated on the caudal peduncle, and extending gradually (at times somewhat irregularly) cephalad: again in contrast to the sequence of events encountered in Phase B, the superolateral and inferolateral regions of the body are here involved contemporaneously (occasionally an odd bar or two becomes discrete first in its superior moiety). Three subphases may conveniently be recognized. *Subphase BCa* (Fig. 10): caudal peduncle with rows of spots; rest of body with bars. *Subphase BCb* (Fig. 11): region caudad of about mid-point of pelvic-anal interspace with rows of spots; region anterior to this barred: commonly, the anterior two (or three) bars that will constitute the adult shoulder-markings now broaden and darken, and, in individuals destined to develop them, the yellow bands between these emphasized anterior bars become more or less pronounced. *Subphase BCc* (Fig. 12): as in BCb, but with tendency towards the breaking-up of one or two bars at, or in advance of, level of pelvic, bars posterior to this still remaining intact.

Basal caudal bar much diminished in width and intensity; suborbital streak and upper labial marking fully developed; dusky tips to pelvic, dorsal, and anal, if present in adult, begin to appear.

Punchbowl Creek specimens in Interphase BC, though occasionally present in late November, do not become common till December or January: they are the characteristic form in February samples, and may exceptionally be taken as late as May. Modal LS 49 ± 3 (Punchbowl Creek): Cox's Creek and Great Lake examples of about the same size were taken in March.

Phase C: Spotted Stage. While the stage immediately following Subphase BCc finds the colour-pattern composed entirely of spots (save for permanent postpectoral bars), adult marking is not yet achieved, Phase C comprising three subphases. *Subphase Ca* (Fig. 13): subvertical bars of subphase Bf wholly resolved into rows of smallish spots. *Subphase Cb* (Fig. 14): regular spot-pattern suffers disruption; linear arrangement of spots, though invariably lost first on caudal peduncle, and persisting longest in head-pelvic interspace, manifests only a general tendency towards progressive disintegration cephalad, frequently occurring discontinuously; concurrently with assumption of random spotting (which involves reduction in frequency, increase in dimensions, of spots) there generally occurs a movement towards the differentiation of the larger spots often present below part, or whole, of dorsal profile, these specialized spots being usually the first to become annulated. *Subphase Cc* (Fig. 15): the normal adult colour-pattern, with scattered large spots, of which many, usually most, are ocellated.

In Punchbowl Creek, fish arriving as fry in October attain the final colour-pattern by about March, or April (exceptionally not till May or even later).

The probable partial correlation of extent of shoulder-markings with age is discussed in subsection (d) below.

(c) **Metrical Characters of Colour-Phases.** Table III exhibits variation, in the three primary colour-phases, of twelve diagnostic body-ratios and fin-ratios: entries for Phase A are based on Series 115 (4 specimens); B, Series 17, 49, 53, 54 (8); C, Series 33, part (10).

TABLE III

GALAXIAS (G.) TRUTTACEUS: VARIATION OF 12 BODY-RATIOS AND FIN-RATIOS IN THE THREE PRIMARY COLOUR-PHASES.

Dimension or Ratio	Colour-Phase	Min.	Max.	$\bar{x}$	σ
Standard length, LS, in mm.	A	45.6	51.6	47.95	2.573
	B	51.0	59.0	54.34	2.777
	C	98.1	109.1	102.66	4.623
Head in LS	A	5.7	6.3	5.90	0.283
	B	4.5	5.0	4.76	0.173
	C	4.8	5.1	4.99	0.477
Depth in LS	A	7.5	8.6	8.20	0.496
	B	5.6	7.6	6.63	0.549
	C	4.3	5.4	4.91	0.324
Eye in head	A	3.5	3.6	3.55	0.058
	B	3.8	4.4	4.04	0.230
	C	4.4	5.4	4.92	0.405
Eye in snout	A	0.9	1.0	0.95	0.064
	B	1.2	1.0	1.13	0.075
	C	1.2	1.5	1.32	0.105
Eye in interorbital width	A	1.2	1.5	1.35	0.141
	B	1.5	1.7	1.58	0.925
	C	2.0	2.5	2.18	0.200
Length of caudal peduncle in LS	A	6.9	7.0	6.98	0.577
	B	6.7	8.9	7.71	0.694
	C	8.3	9.9	8.94	0.498
Depth of caudal peduncle in its length	A	1.8	2.0	1.90	0.082
	B	1.3	1.7	1.45	0.165
	C	1.3	1.4	1.35	0.075
Length to pelvic fin in LS	A	2.11	2.14	2.12	0.0153
	B	1.95	2.02	1.99	0.0229
	C	1.82	1.98	1.89	0.0054
Length to dorsal fin in LS	A	1.43	1.49	1.46	0.0271
	B	1.40	1.47	1.42	0.0332
	C	1.35	1.38	1.38	0.0167
Length of pectoral fin in pectoral-pelvic interval	A	2.4	2.7	2.48	0.141
	B	1.8	2.1	2.01	0.105
	C	1.8	2.1	1.92	0.120
Length of pelvic fin in pelvic-anal interval	A	2.2	2.3	2.25	0.082
	B	1.6	2.1	1.91	0.015
	C	1.6	1.9	1.78	0.100
Combined base of dorsal and anal fins in LS	A	3.8	4.2	3.98	0.208
	B	3.8	4.2	3.97	0.141
	C	4.2	4.9	4.54	0.691

Table III shows: (i) points of origin of dorsal and pelvic constitute important morphological landmark, subject, in a given length-class, to little individual variation: (ii) with increase in LS, relative length of head appears, on present data, first to decrease, then slightly to increase; results are perhaps exceptional, normal course probably being a progressive decrease: (iii) with increasing LS eye becomes smaller, relative to head, snout, interorbital width; body grows deeper; caudal peduncle becomes deeper, also shorter relative to LS; lengths to dorsal and pelvic origins increase; combined bases of vertical fins become relatively smaller; lengths of pectoral and pelvic, relative to fin-interspaces, increase: (iv) except that of combined bases of vertical fins, in which there is no significant difference on average between Colour-Phases A and B, all changes noted in (iii) are clearly progressive, and ratios yield distinctive figures for each colour-phase.

(d) **Colour Varieties.** Johnston (1883, p. 131) states: 'There are two or three varieties: Var. *a*.—In the North Esk, without the three characteristic cross-bars upon the shoulder. Var. *b*, Mountain Trout.—Without spots or bars; head more depressed. Colour, grey, with beautiful iridescent specks of green and gold. Mount Wellington. Var. *c*.—A red-finned variety, found in streams at Gould's Country'. Regan (1906, p. 379) admits: '*A. Forma typica*, with 2 or 3 dark vertical bars above the pectoral and with the dorsal, anal, and ventral fins blackish at the tip [all his specimens from Tasmania]: B. Variety without bars above the pectoral, with the fins uniformly pale' two specimens from Moorabool River, Victoria [Johnston's reference to Tasmanian examples without bars above pectoral noted].

Examination of the present material yields the following results. (i) *General Body-Colour*: greyish, greyish green, pale green, dark green, yellowish green, yellow, yellowish pink, greyish purple, and other tints; some West Coast specimens (e.g., Series 88, 120) very dark purplish, almost black. (ii) *Pectoral*: usually colourless, but may be greyish or greenish, becoming somewhat lighter or somewhat darker distally; not tipped with black. (iii) *Dorsal and Anal*: virtually colourless; almost colourless proximally, faintly dusky distally (common); pale brownish proximally, becoming nearly colourless or darkening almost to black distally; yellowish, with or without black margins (common); successively from base, about one-fourth olivaceous or pale yellowish, five-eighths bright reddish orange or brownish red, one-tenth black, one-fortieth pale ashen (a common succession). (iv) *Shoulder-Bar*: number and extent of bars may vary on two sides of same individual; bars at times absent, but if so, shoulder-region usually bears one or more dark blotches larger than general body-spots; bar usually margined, anteriorly, posteriorly, or both, with area lighter or brighter than general body-colour, this area frequently being, in small specimens sulphur-yellow—there is some evidence to suggest number and distinctness of bars vary with age, Punchbowl Creek specimens of LS 50-60 usually having two prominent bars with conspicuous sulphur-yellow interspace (whole pattern quite apparent in living fish several yards away in water), larger individuals often showing only a single bar; in many series bars are more numerous, relatively larger, and better defined in small than in large fish; in Great Lake material of fair size there is commonly one bar (often relatively smaller in larger specimens), or none, and, in the majority of cases, a moderate or smallish blotch above superior angle of operculum. (v) *Dark Suborbital Streak*: constantly present. (vi) *Upper Lip*: regularly dark. (vii) *Ocellated Spots*: the development of the ocellus, which does not always involve all body-spots, appears to be largely a function of age. (viii) *Spots on Head*: two or three dark spots on operculum, one or two on preoperculum,

sometimes present: body-spots extending on to dorsal surface of head only exceptionally. (ix) *Gold-specking*: quantity present varies considerably; characteristically much more pronounced in material from high altitudes.

While further investigation on colour varieties is needed, these facts suggest the following observations. (i) There exists no sharp line of demarcation between Regan's A (= Johnston's Var. *a* from North Esk) and Regan's B—thus, we find examples with shoulder-bars and pale fins (Series 86), and with black-tipped fins, and no well-defined shoulder-bar (Series 118)—nevertheless, it remains true that specimens with fins uniformly pale, or with slight distal duskiness in pelvic, dorsal, anal usually, though not invariably, have the post-pectoral bars reduced to blotches, considerably, or occasionally but slightly, larger than ordinary body-spots: such a form occurs not only in the North Esk (where it is associated with other varieties), but in many widely separated localities, including the Central Plateau, where it is common. (ii) Johnston's Var. *c*: specimens with red, black-tipped fins (body usually yellowish or pinkish) are apparently common (Series 30, 60; Pyengana) near Johnston's locality, but are by no means confined to this district (cf. Series 99, 110). (iii) Of Johnston's Var. *b* (the term 'Mountain Trout', applied by Johnston to this form, is now used indiscriminately for all forms of *G. (G.) truttaceus*, wherever found; often, indeed, also for other species of *Galaxias*) no specimens appear to exist in Museums, nor have I been able otherwise to secure any: while, in the absence of material, surmise only is possible, I am much inclined to believe this reference to an unspotted form relates to another species altogether, possibly *G. (G.) affinis*, which seems to agree reasonably well with Johnston's brief description.

SPAWNING

(a) *General*. There is no published information on the spawning habits of *G. (G.) truttaceus*. As already suggested, it seems not unlikely that, where circumstances permit, this species migrates to brackish water, possibly even to the sea, to spawn. It is noteworthy that fish with ripe ova are not infrequently secured (Series 33, 77, 110) in localities at, or near, the coast.

(b) *Number and Size of Ova*. Before extrusion, the ova are discharged, as in the Salmonidae, into the abdominal cavity. In a specimen of LS 113 (Series 33) there were counted 5643 ova, of modal diameter (in formalin) of 1.0-1.3 mm.

(c) *Spawning Season*. Specimens with the abdomen markedly distended with masses of ripe ova are taken in April and May. Fish have been stripped, in several seasons, in both these months; but attempts to hatch ova have hitherto proved unsuccessful.

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PLATE IX

Galaxias (G.) truttaceus Cuvier: COLOUR-PATTERN PHASES

Except in the case of Fig. 14, which represents a specimen from Cox's Creek, Wynyard, the normal sequence of colour-pattern phases (Figs. 2-15) is illustrated by fish from Punchbowl Creek, Launceston. For dates of collection of various Series see text.

For the sake of clearness, the pectoral fin is omitted: details of the remaining fins, other than colour-pattern (where present), are not shown.

Colour-Phase A: Unornamented Stage

FIG. 2.—Series 115.

Interphase AB: Preliminary Pigmentation Stage

FIG. 3.—Series 145.

Colour-Phase B: Barred Stage

FIG. 4.—Subphase Ba. Series 145.

FIG. 5.—Subphase Bb. Series 90.

FIG. 6.—Subphase Bc. Series 91.

FIG. 7.—Subphase Bd. Series 90.

FIG. 8.—Subphase Be. Series 91.

FIG. 9.—Subphase Bf. Series 146.

Interphase BC: Barred-Spotted Stage.

FIG. 10.—Subphase BCa. Series 92.

FIG. 11.—Subphase BCb. Series 92.

FIG. 12.—Subphase BCc. Series 45.

Colour-Phase C: Spotted Stage

FIG. 13.—Series 156.

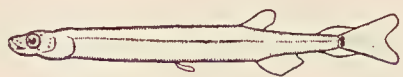
FIG. 14.—Series 34.

FIG. 15.—Series 166.

Variations

FIG. 16.—Specimen from Cox's Creek, Wynyard, showing greater distinctness of barring than that characteristic of Punchbowl Creek specimens. Series 17.

FIG. 17.—Occasional departure from normal sequence, involving formation of some entire bars prior to complete development of superolateral series of half-bars. Series 91.



2



3



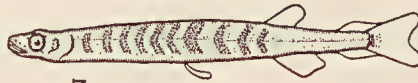
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9



10



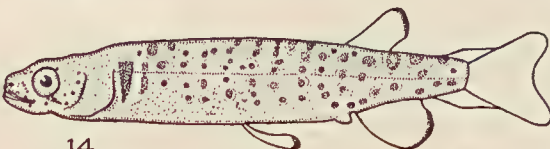
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12



13



14



SCALE : MM.



15



16



17

NATIONAL MUSEUM OF VICTORIA

Additions and Corrections to *Orchidaceae* of Tasmania

By

W. H. NICHOLLS AND A. M. OLSEN

(Read 11th November, 1940)

Prasophyllum Rogersii Rupp

Plant slender, 20-30 cm. high. Leaf-lamina sometimes exceeding the inflorescence. Flowers in a loose spike, not very numerous, green, the labellum white. Fragrant.

Pedicels very short. Dorsal sepal nearly straight, broad-ovate, acute, 5.5 mm. long, with three prominent nerves and a finer one on each side. Lateral sepals free, more or less spreading, lanceolate, somewhat longer than the dorsal one, hardly acute, 3-nerved. Petals erect, not widely spread, obtuse, fairly broad. Labellum straight for two-thirds of its length from the base, the anterior third merely curved, not sharply reflexed, broadly-ovate, contracted towards the apex; membranous part white, sometimes flushed with pink; margins entire; greatest width about 2.75 mm.; callous part prominent, especially beyond the curve, broader towards the base. Column short, lateral appendages broad. Anther broad, red-brown.

(*Pr. patens*, R.Br. its nearest affinity.)

Distribution: This rare orchid was first recorded and described in 1928 from material collected on Barrington Tops in New South Wales (alt. 5000 ft.). Tasmanian habitat: Knocklofty, near Hobart (alt. 1200 ft.). Collector: A. M. Olsen 1936-1939.

Flowering: December.

Prasophyllum patens R.Br., var. *robusta* Nicholls

Plant more robust than the typical form, about 40 cm. high. Flowers 2 cm. in diameter; spike loose; segments of the perianth widely-spread. Ovary 1-2 cm. long (unusually large for so small a flower). Petals narrow-linear.

Habitat: Smithton. Collector: Archdeacon Atkinson.

Flowering: October.

Prasophyllum alpinum R.Br. (Syn. *Pr. Tadgellianum* Rogers)

Habitat: Mt. Wellington. Collector: Dr. C. S. Sutton. Included under *Pr. fuscum*, R.Br. in 'The Tasmanian Flora', Rodway (1903). See Nicholls, Proc. Roy. Soc. Vict., XLVI (1933), pp. 31-33.

Prasophyllum Brainei Rogers

A slender wholly green plant 12-35 cm. high. Flowers often very numerous, green. Labellum white, sessile, forming a complete sigmoid flexure; margins crenulate, very shortly ciliate; callous part green, margins ciliate.

Distribution: Victoria, Tasmania. Tasmanian habitat: East Bank of Don River (North Tas.). Collector: Archdeacon Atkinson.

Flowering: September to January. Very plentiful in habitats.

Calochilus imberbis Rogers. 'Beardless Calochilus'

Habitat of plant similar to *Cal. Robertsonii* Benth. Plant 20-37 cm. high. Leaf rigid, fleshy, channelled, linear-lanceolate. Flowers racemose, 3-6 (in Tasmanian specimens), green with purplish markings—chiefly striae. Dorsal sepal cucullate, lateral sepals free, ovate, acute. Petals triangular-falcate, conspicuously marked with purplish veins. Labellum petaloid, sessile, simple, ovate, acute; margins entire, with 7 conspicuous purplish nerves; lamina without calli, hairs or other processes. Column short, the wings connected in front by a high shield-like plate, a purple gland at the base of each.

This plant is well separated from others in the genus by its simple labellum.

Distribution: Victoria, Tasmania. Tasmanian habitat: Woodbridge. Collector: Miss A. M. Wall.

Flowering: October.

Thelymitra grandiflora Fitzgerald

The most beautiful of all the Thelymitras. Tasmanian specimens received had large flowers with the column hairtufts golden-yellow.

Habitat: Low Head. Collector: Mrs. F. Perrin.

Flowering: October, November.

Thelymitra rubra Fitz.

In place of *Th. carnea* R.Br. in 'The Tasmanian Flora' (p. 189). *Th. carnea* (Syn. *Th. Elizabethae* F. Muell.) is a smaller plant found only in Victoria and New South Wales.

Corysanthes dilatata Rupp et Nicholls

In place of *C. pruinosa* Cunn. Cunningham's species is restricted to New South Wales.

Pterostylis grandiflora R.Br.

A slender plant 15-35 cm. high. No basal leaves at time of flowering. Stem-leaves lanceolate, acuminate. Flower solitary, white with fine green striae and rich red-brown markings; galea erect then gracefully curved forward, then decurved; apices acute, dorsal point 1 cm. long. Petals widely expanded, red-brown, inner surface often crimson-brown. Lower lip with a flattened sinus, lip projecting, filiform points erect, exceeding the galea by about 4 cm. Labellum irritable, lamina oblong-linear with a long filiform-clavate apex.

This species is often referred to as 'Queen of Greenhoods'.

Flowering (in Tas.): February-August. (May to September on Mainland.)

Distribution: S. and E. Vic., N.S.W.; Q'land; Tas.

Habitat in Tasmania: S.E. side of Flagstaff forming Northern end of Scamander Tier. Collector: A. C. Smith.

***Pterostylis vereenae* Rogers**

A wholly green plant similar to *Pt. furcata* Ldl. Basal leaves large, sessile, stem-bracts 2. Very large and leaf-like.

Habitat in Tasmania: Mt. Bischoff. Collector: Archdeacon Atkinson.

Flowering: September-October.

Distribution: South Australia, Tasmania.

A very rare species.

***Pterostylis foliata* Hk.f. (Syn. *Pt. gracilis* Nich.)**

A slender species 12-30 cm. high. Stem-leaves oblong lanceolate, stem-bracts large. Flower solitary, small, green with apex of galea brown. Labellum oblong-elliptical, tip often decurved.

Resembling *Pt. pedunculata* R.Br. in general appearance but easily separated by having larger leaves and stem-bracts, &c. Perhaps more closely related to *Pt. alpina* Rogers but in this case distinguished by the smaller more deeply coloured flower, &c.

Distribution: New Zealand, Victoria, Tasmania.

Tasmanian habitats: Devonport to Smithton (Collector: Archdeacon Atkinson); Mt. Nelson, Mt. Wellington, Launceston (Rev. H. M. Rupp).

Flowering: August-November.

***Pterostylis decurva* Rogers**

In place of *Pt. obtusa* R.Br. in 'The Tasmanian Flora' (p. 198). *Pt. obtusa* is found in Vic., S.A., N.S.W., and Queensland; whilst *Pt. decurva* occurs in Tas., Vic., and N.S.W. Common in mountain districts.

Flowering: October to February, according to altitude.

The detailed description (under *Pt. obtusa*) by Rodway is a good one.

***Pterostylis Toveyana* Ewart et Sharman**

Plant 8-20 cm. high. No basal rosette of leaves at time of flowering. Stem-leaves oblong-ovate or ovate. Flower solitary, green with copper-brown markings. Labellum slightly notched at the apex.

Distribution: Victoria, Tasmania.

Flowering: July-August. Tasmanian habitats: Sandford, Eaglehawk Neck, Flinders Island. Collector: Archdeacon Atkinson.

***Caladenia cordiformis* Rogers**

In place of *Caladenia clavigera* Cunn. in 'The Tasmanian Flora', (p. 204). This detailed description of *C. cordiformis* is typical of the species.

Distribution: Widely distributed in Tas., N.S.W., and Vic.

Tasmanian habitats: Bellerive, Georges Bay, &c.

Flowering: November-December.

***Chiloglottis Pescottiana* Rogers**

(Rogers, Proc. Roy. Soc. Vict., XXX (1933), pp. 139-141.)

A slender plant 8-18 cm. high. Leaves on long petioles, oblong-lanceolate. Flower solitary, greenish-bronze or wholly purplish, with dark-purple calli; lateral sepals linear-lanceolate, recurved, connate at extreme base; dorsal sepal spathulate-acuminate; lateral petals spreading, lanceolate; labellum oblong; calli distributed as follows:—(1) one large crescentic sessile callus in middle line in advance of

all the others; (2) a large bilobed stalked callus about midway between this and base of lamina; (3) numerous stalked calli, small and medium sized, between (1) and (2); (4) a somewhat irregular row of small stalked calli on either side of the middle line from the bend in the lamina to its base. Column winged above; Anther blunt.

Flowering: September-November.

Original habitat on the Mainland: Cravensville (in N.E. Vic.). Original Collector: Mr. A. B. Braine (1907).

Tasmanian habitat: Mt. Barrow. Collector: Mrs. Pearl Messmer of Sydney (N.S.W.), (1940). 'Large colonies interposed between plants of *Chiloglottis Gunnii* Ldl. and *Chil. Muelleri* Fitz.'

The Royal Society of Tasmania

1940

Patron:

His Majesty the King.

President:

His Excellency Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E.

Vice-Presidents:

W. H. Clemes, B.A., B.Sc., retires 1941.

E. E. Unwin, M.Sc., retires 1942.

Council:

W. L. Crowther, D.S.O., M.B., retires 1943.

A. L. Meston, M.A., retires 1943.

V. V. Hickman, B.A., D.Sc., retires 1942.

A. N. Lewis, M.C., LL.D., M.H.A., retires 1942.

H. Allport, LL.B., retires 1941.

N. P. Booth, retires 1941.

Standing Committee:

W. L. Crowther, A. N. Lewis, V. V. Hickman, J. Pearson.

Hon. Treasurer:

S. Angel.

Hon. Editor:

Joseph Pearson, D.Sc., F.R.S.E., F.L.S.

Hon. Auditor:

Walter E. Taylor, F.F.I.A., F.I.A.S.

Secretary and Librarian:

Joseph Pearson, D.Sc., F.R.S.E., F.L.S.

Annual Report

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, Hobart, on the 11th March, 1940.

The following Office-bearers were elected:—

Under the Society's Rules Dr. W. L. Crowther retired from the office of Vice-President, and Mr. E. E. Unwin was appointed in his place (retiring 1942).

Treasurer: Mr. S. Angel.

Under the Rules Mr. W. H. Hudspeth and Dr. J. W. Evans retired from the Council, and the following members of Council were elected in their place:—

Dr. W. L. Crowther (retiring 1943).

Mr. A. L. Meston (retiring 1943).

Mr. N. P. Booth was elected to the Council to sit for the unexpired portion of Mr. Unwin's period, namely, one year.

The Council made the following appointments at its first meeting:—

Secretary and Librarian: Dr. Joseph Pearson.

Assistant Librarian: Mrs. Clive Lord.

Standing Committee: Dr. W. L. Crowther, Dr. A. N. Lewis, Dr. V. V. Hickman, and the Secretary.

The Council elected the following two Trustees to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery and the Botanical Gardens in accordance with the amended Tasmanian Museum and Botanical Gardens Act:—Mr. W. H. Clemes and Dr. A. N. Lewis.

Ten meetings were held during the year (see proceedings for abstract of papers). In addition scientific papers were submitted for publication and have been printed in the present volume.

Library

It was agreed, on the recommendation of the Council, to make the following change in the hours of opening the Society's Library:—

That members make use of the Library for reading purposes only when the Assistant-Librarian is present at the following times:—Mondays, 10 a.m.-1 p.m.; Wednesdays and Fridays, 10 a.m.-1 p.m., 2-5 p.m.; on the evenings when a General Meeting is held, 7.30-8 p.m.

During the year 330 volumes were added to the Library in addition to a number of reports and pamphlets from British and foreign countries. The number of Institutions on the Exchange List for the year was 278, being made up of 131 British, 53 American, and 94 from other parts of the world. The Library now consists of 19,889 volumes.

The sum of £34 17s. 3d. was spent on books during the year, and the account was allocated as follows:—

	£	s.	d.
General Fund	10	2	5
R. M. Johnston Fund	8	15	0
Morton Allport Memorial Fund	11	7	5
Beattie Memorial Fund	4	12	5

In addition the Tasmanian Museum spent £6 16s. 1d. on books, which have been placed in the Society's Library for safe-keeping and are available to members.

Membership

The Society consists of the following members:—

	1939.	1940.
Honorary Members	2	2
Corresponding Members	3	3
Life Members	7	7
Ordinary Members	240	227
Associate Members	3	6
	255	245

During the year 21 names were removed from the Membership owing to deaths, resignations, &c., and 8 new names were added.

The Council regrets having to record the death of Sir Herbert Nicholls during the year.

Resignation of Auditor

The Council has accepted with much regret the resignation of Mr. Walter Taylor, both as a member of the Society and as Auditor. Mr. Taylor has rendered valuable work as Auditor since 1926, and his resignation has been caused by his removal to another State.

Royal Society Medal

Two medals of the Royal Society of Tasmania were presented during the year, both at the July meeting, one to Dr. W. L. Crowther for his contributions to Tasmanian ethnology, and one to Dr. V. V. Hickman for his researches on Tasmanian zoology, particularly his work on Tasmanian spiders and the early development of anaspides.

Printing of Papers and Proceedings

Once again the Government has very generously printed the Papers and Proceedings. The Council wishes to record its appreciation of this generous assistance.

Abstract of Proceedings

8TH FEBRUARY, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, Sir Ernest Clark, K.C.B., K.C.M.G., C.B.E., presided.

Professor A. E. V. Richardson, C.M.G., M.A., D.Sc., Deputy Chief Executive Officer of the Commonwealth Council for Scientific and Industrial Research, gave a lecture on 'Scientific Research in Relation to Industry'.

Professor Richardson said that the demand for assistance for scientific research in agricultural problems was so great that the Council for Scientific and Industrial Research had now about 600 workers engaged in research on primary problems. He emphasized that the central aim of the national policy should be the development of primary industries to the highest attainable level and the organisation of the rural population as an important part of the political and social fabric of the nation. He went on to show that the investment which Australia had made in research had paid magnificent dividends and the improvement in production had benefited farmers, consumers, and society as a whole. So far as the future was concerned there were immense developments still to take place in Australia's primary industries.

Professor Richardson went on to show that, although primary production in Australia had expanded enormously during the past generation, there was an actual reduction in numbers now engaged in agricultural pursuits. For example, in 1913 there were 211,000 male persons engaged in agriculture, and, despite the tremendous developments since that date, the present number was only 189,000. That was mainly due to the mechanization of production. It was not in agriculture, therefore, that Australia could hope to absorb large numbers of new settlers. Migration must be definitely linked with industrialization. What was needed was a well-balanced economy which would envisage the full development of the mineral, power, forestry, fishery, and agricultural resources of the Commonwealth and the establishment of such manufacturing industries as are dependent upon them.

11TH MARCH, 1940

The Annual Meeting was held in the Society's Room, Tasmanian Museum, the President, His Excellency the Governor, presiding.

The following were elected Office-bearers and members of the Council for 1940:—Mr. E. E. Unwin was elected Vice-President in the place of Dr. W. L. Crowther, who retired under Rule 12; Dr. W. L. Crowther and Mr. A. L. Meston were elected in the places of Mr. W. H. Hudspeth and Dr. J. W. Evans, who retired under Rule 21; Mr. N. P. Booth was elected to the Council for the unexpired portion of Mr. Unwin's period, namely one year: Treasurer, Mr. S. Angel.

Mr. Walter Taylor was appointed Hon. Auditor.

It was agreed, on the recommendation of the Council, to make the following change in the hours of opening the Society's Library:—

That members should make use of the Library for reading purposes only when the Assistant Librarian is present at the following times:—Monday, 10 a.m.—1 p.m.; Wednesdays and Fridays, 10 a.m.—1 p.m., 2—5 p.m.; 7.30—8 p.m. on evenings when a General Meeting is held.

It was also suggested that, if members wished to use the Library on Saturday mornings, this might be arranged instead of a half day during the week.

Mr. H. O'May gave an illustrated lecture on 'The Ship Building and Sea Faring Pioneers of Tasmania' of which the following is an abstract:—

These pioneers played a very important part in the development of the Island State, but, as Tasmania was a penal settlement, the free colonists were not allowed to build or own vessels, and, as the vast landlocked waters at the estuary of the Derwent abounded with the black whale in the breeding season, those early settlers were forced to stand by and witness thousands of pounds worth of whale oil taken by Port Jackson and English whale ships, and they were not allowed to participate. This of course caused much discontent, and it was some years before these restrictions were removed.

Then convenient places were chosen around the foreshores, suitable bluegum trees selected, saw-pits dug, and keels, frames, planking, and fastenings of tree-nails prepared.

This Tasmanian timber proved to be second to none for shipbuilding purposes, trees could be found up to 150 feet, straight up to the first limb, this was a great advantage, as it allowed the keels, keelsons, and stringers, &c., to be cut in one length, and the breaking strain of this splendid timber was above that of English oak or teak.

The first square-rigged vessel known to be built on the shores of the Derwent was the *Campbell Macquarie*, a brig of 133 tons. She was built by Samuel Gunn for R. W. Loan, a merchant of the city, and was launched in Sullivan's Cove in 1813.

Vessels were built at New Town Bay, Rosny Point (then known as Canadian Point), Brown's River, Pittwater, Port Davey, Macquarie Harbour, Port Arthur, Bruny Island, and the Huon River, some for the flourishing whaling trade (the price for whale oil then ranged from £25 to £120 per ton), and others were engaged in inter-colonial, and quite a number for the Home, trade. These little Tasmanian built vessels poked their long flying jib-booms into many ports of the world, and wherever they went they were admired, by men who understood the sea and ships, for their staunchness of construction, their model, and rig.

Amongst the builders were David Hoy, Thomas Florence, W. Maycock, Johnson, Peter De Graves, Williamson, Gray, Callaghan, C. Chessell, John Ross (who laid down the first patent slip in 1854). Perhaps the best-known was John Watson, who launched many fine vessels, amongst them the historical whaler *Flying Childers*, and he also taught many young Tasmanians the art of ship-building. Such past-masters as John, Alexander, and James McGregor, John Lucas, James Mackey. All these yards turned out some splendid vessels, such as the *Harriet McGregor*, *Loongana*, *Waratah*, *Oceana*, *Nautilus*, all noted for their models and speed. The largest vessel, *Tasman* (560 tons), was launched by Peter De Graves in March, 1847. Johnson, from his yard at Kangaroo Point in 1838, launched the barque *Sir George Arthur*, a vessel of about 400 tons, build for Petchey, and it was the first Tasmanian-built vessel to enter the London trade.

Callaghan built the first steamer in Tasmania. He set afloat the *Governor Arthur* from his yard in Sullivan's Cove in 1832. This little vessel was built for the Kangaroo Point ferry service.

Charles Chessell was responsible for the first ship-rigged vessel when he launched the *Maria Orr* for William Morgan Orr. This ship was built on the spot where the Shell Oil Tank now stands.

Williamson built many fine vessels. Amongst them were the *Harriet Nation* and *Margaret Brock*. John Ross, from his yard at Secheron Point, launched the *Thomas Brown* and *Isabella Brown*.

The last barque-rigged vessel built was the beautiful little *Loongana*, set afloat by John McGregor from his yard on the foreshore of the Domain in 1878.

The number of vessels built at Hobart from 1825 to 1872 was 313, with a tonnage of 19,959.

In 1919 Purdon and Featherstone launched from their yard at Battery Point the *Valmarie*, a fore and aft three-masted schooner of 256 tons.

H. McKay built, on the shore of the Channel, the three-masted fore and aft schooner *Kermandie*, 342 tons; and F. and H. Moore built and launched from Battery Point the three-masted topsail schooner *Amelia J*, 352 tons, for H. Jones and Co. This splendid little blue-gum clipper was lost with all hands on a voyage from Newcastle to Hobart in 1920.

Tasmanian seafarers were also known for their seamanship. This can be easily understood, for the island depended on them for its existence, and those little vessels kept the trade alive and the wheels of industry turning; and what a training ground for the young native-born on the broad almost tideless reaches of the Derwent. With the splendid wide stretches of land-locked waters at its estuary they could not be otherwise than expert seamen.

8TH APRIL, 1940

A meeting was held in the Society's Room on this date. Mr. W. H. Clemes presided in the absence of the President.

The following were elected members of the Society:—Ordinary Members, Miss W. M. Curtis, Mr. John Dow, Mr. A. M. Olsen; Associate Members, Mr. H. A. Winter, Mr. P. J. Bowling.

Dr. W. L. Crowther raised the question of the condition of the grave head-stones in St. David's Park, and the following motion was moved by him and seconded by Miss C. Travers, and the resolution was carried: *That members of the Royal Society recommend that action be taken by the City Council to safeguard the condition of the head-stones in St. David's Park, to have the lettering on the stones improved, and to make the head-stones more accessible for inspection by the public.*

Dr. H. D. Gordon gave an illustrated lecture on 'The Vegetation of the Beach', of which the following is an abstract:—

Sand is constantly being deposited on the beach by the sea, and as the surface dries at low tide it is blown inwards; plants and other obstacles cause it to heap up, forming sand-dunes.

Plants which grow in mobile sand must possess wide-spreading roots and runners capable of holding the sand, and must also have a vigorous upward growth to cope with the sand which is constantly being blown on top of them. In this way they build up higher and higher sand-dunes. The most efficient dune-former and sand-binder is the introduced Marram grass, but a number of native plants, such as the coast fescue, spreading sedge, and shore wattle are also effective sand-binders. Numerous other plants can establish themselves when these pioneers have brought some stability to the sand.

Often high winds will undo the work of the sand-binders and cause disintegration of the dunes; and persistent on-shore winds may keep the sand moving inland so as to cover adjacent land.

On sheltered beaches there is often a level strip of sand above high-water mark but in front of the dunes, which is inhabited by a distinct colony of strand plants, such as the sea rocket and glistening saltbush. These small plants form miniature dunes by accumulating small quantities of blown sand, but are incapable of surviving on the exposed beaches where movements and accumulation of sand are rapid.

Miss W. M. Curtis gave a paper on '*Spartina Townsendii*, its History and Economic Value in Reclaiming Tidal Mud', of which the following is an abstract:—

Spartina Townsendii, a grass inhabiting tidal mud, was first recorded in 1870 from the salt marshes of the South of England; ten years later it was recognized by H. and J. Groves as a distinct species. Although the plant bred true from seed, it was suggested that it might be a hybrid between *Spartina stricta*, which is indigenous to Europe, and *Spartina alterniflora*, introduced from America at the beginning of the nineteenth century.

An investigation of the floral morphology gave no clue to the origin of the plant, but the hybrid hypotheses was confirmed in 1930 by the cytological work of Huskins. He found the somatic chromosome numbers of the European representatives of the genus *Spartina* to be:—*S. stricta*, $2n = 56$; *S. alterniflora*, $2n = 70$; *S. Townsendii*, $2n = 126$. Huskins therefore found *S. Townsendii* to be 'an allopolyploid derived from the doubling of the chromosome number in the original hybrid plant.'

The new species has proved a rapid and effective colonizer of tidal mud, and has spread naturally to cover scores of square miles of country throughout the salt marshes of the south of England and the north of France. It has been planted on a large scale in Holland, where the resultant stabilization of the mud and rapid rise in level of the marsh have led to a very considerable acceleration in the operations of poldering and complete reclamation of land. *S. Townsendii* has recently been introduced to Australia, where small-scale experiments are in progress in various localities.

13TH MAY, 1940

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

Mr. B. W. Rait read a paper entitled 'A Century-Old Dictator', dealing with the life of Jorgen Jorgenson.

Born in Copenhagen in 1780, Jorgenson served as an apprentice in an English collier at the age of 14. After four years he transferred to a whaler, and made his way to Cape Town, where he joined the *Harbinger*, in which vessel he came to Australia in the year 1800. On the way out, King Island was discovered and named. In New South Wales, Jorgenson joined the brig *Lady Nelson* as second mate, and witnessed first the foundation of the first settlement on Van Diemen's Land at Risdon in September, 1803, and later the vain effort to establish a settlement at Port Phillip by Lieutenant-Colonel David Collins in October, 1803. He was on board the *Lady Nelson* during the exploration of the River Tamar in January, 1804, and in February took part in the foundation of Hobart. He left the *Lady Nelson* to join the whaler *Alexander* as chief officer, and claimed that, on a visit to the Derwent in this ship, he killed the first whale in the river. Returning to England in 1806 he crossed to Copenhagen, where he obtained command of a privateer *Admiral Juul*, in which he attacked the H.M.S. *Sappho*, and was compelled to strike his colours. He was taken to Yarmouth as a prisoner of war, and it was whilst on parole that he embarked upon an expedition to Iceland. This was in December, 1808, and on the second visit in June, 1809, he organized the dramatic coup that made him the self-styled 'Lord Protector of Iceland.' Ultimately, he was deposed, and, after many misfortunes, broke the law, and was transported to Tasmania for life, where he died in 1841.

Mr. E. T. Emmett also delivered an illustrated lecture on 'Early Days of New Norfolk', of which the following is an abstract:—

Sir John Hayes visited what is now the settlement of Hayes in 1793, and named the Derwent, Cornelian Bay, Mt. Direction, and Risdon. The Rev. Robert Knopwood also visited the district in 1804, and in 1807 Lieut. Laycock, on his way from Launceston to Hobart, stopped there. Governor Macquarie named the settlement Elizabeth Town in 1811, but the real genesis of the settlement might be said to be in the deportation of Norfolk Islanders to Australia in 1803. Elizabeth Town did not progress, and the district called New Norfolk, after the Norfolk Islanders, became the town. Mr. Emmett traced the history of the churches at New Norfolk and of various other places of interest connected with the growth of the settlement.

10TH JUNE, 1940

A meeting was held in the Society's Room on this date. In the absence of the President, Mr. E. E. Unwin, Vice-President, presided.

Miss J. W. Richardson was elected an Associate Member.

Mr. Clemes proposed, and Dr. Pearson seconded, that Dr. W. L. Crowther and Dr. V. V. Hickman be awarded the Royal Society of Tasmania Medal. This was carried unanimously.

Mr. E. O. G. Scott gave an illustrated lecture on 'Fish and Fish-like Animals', of which the following is an abstract:—

An introductory section dealt with some of the principal lines of contemporary research on fishes, and included reminiscences of prominent ichthyologists in various parts of the world.

The main groups of fish-like animals were enumerated: their affinities were discussed, and reasons for excluding them from the Class Pisces briefly noted.

Short accounts, illustrated by lantern slides, were given of recent researches in such fields as fish locomotion (Gregory, Breder, Green, Harris); mass-psychology (Schuett; Breder, and Nigrelli; Escobar, Minahan, and Shaw); round-about path of the Fighting Fish, *Betta splendens* Regan (Beniuc); antagonism and toxicity (Ellis, James); statistical researches on North Sea fisheries (D'Arcy W. Thompson, Graham); food of *Salmonidae* (Neill); influence of pH on rate of growth (Southern); life-histories of Australian pelagic fishes (Dakin, Cölefax); matroclinous inheritance in *Mollienisia* (Hubbs); etc.

8TH JULY, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presided.

The Royal Society of Tasmania Medal was presented by His Excellency to Dr. W. L. Crowther and Dr. V. V. Hickman, and they replied.

Miss C. H. Wedgwood delivered an illustrated lecture on 'The Economic Life of a New Guinea People', of which the following is an abstract:—

The lecture dealt with the Island of Manam, which lies about ten miles to the east of the coast of New Guinea in Lat. 4° 30' S. The islanders live in thirteen villages along the foreshore. These are composed of a number of separate homesteads occupied by members of a single family, those of the same clan forming usually a small hamlet. Each village has its own chief (*tanepwa*), who formerly had considerable authority and still plays an important part in the social and economic life. He is always the senior male member of the clan of the original founder of the village; the other clans also have their headman, who are leaders in all clan undertakings. Inter-marriage between the villages is usual, but each village is composed of different clans and is an independent entity.

There are certain misconceptions about the economic life of primitive peoples: that the women are drudges and the men drones; that natives are by nature lazy and only work for material necessities; that there is no specialization, and hence no organization, of labour; everyone working for his own individual family; that private ownership of land and goods is unknown, a kind of communism being the custom. To show how completely these are misconceptions three types of economic activity were described: gardening, house-building and canoe-building, and overseas trade.

Each village has its own tract of bush land, which is subdivided between the clans and of which the individual men and women have rights in garden ground. Ground is cultivated for two years and then left fallow for six or seven years. The clearing is done by a man with the help of his kinsmen, and they help the women with the planting. A woman with her younger children does the day-to-day weeding in her own or her husband's garden, but he often goes with her to help. There is no true harvest since the crops cannot be stored, but are dug as they are needed. Once a year, however, a village invites a neighbouring village to a festival at which the visitors dance and hosts make large gifts of food: this is reciprocated a few days later. The exchange has no significance as trade, but is of very great social importance. Generosity with food is expected of all people: all important social occasions (births, marriages, funerals, puberty ceremonies) are marked by feasts or a distribution of food. The crops which a man and his wife grow are never consumed only by themselves and their children; they are caught up in an intricate net-work of social obligations.

There are two types of house; one built on the ground and used by a man; the other raised off the ground on piles which is the woman's domain. The latter is the more important. In building such a house a man is helped by his male kinsfolk, while his wife and female kinsfolk prepare food for the workers. Kinsmen may also help by contributing wood for the building and coconut leaves for the thatch. The hearth, made up of layers of sand, fern and plaited coconut leaf, is always set in place by the woman who is to use it—the mistress of the house.

Manam is not self-contained, and it has always had to depend on the mainland. Every man and many women have in one or more mainland villages an hereditary "trade partner" (*tawa*). Only in this way was trade between normally hostile villages possible. Special, large, overseas canoes are built for the trading expeditions, and on their construction and beautification much labour is expended. Each clan has the right to build such a canoe, though the head man is spoken of as its owner, and it is he who organizes its construction and requites the workers with food and feasts. The most important canoe is that of the village chief. All the villagers, as well as his kinsmen in other villages, are expected to help build this. During the process of canoe-building, magic is made, not only to ensure that the vessel shall sail well, but also that it may attract to it the wealth of the mainland villages so that the trading expeditions may be prosperous.

European and native attitudes towards work and ownership of property are sufficiently different to lead to misunderstanding and conflict. To the native most work is a social activity and is creative with a definite emotional tone. The co-operative method of work and the custom of gift exchange serve to bind the community together, and have therefore much more than a merely economic significance. Reciprocity is the basis of all social relations.

12TH AUGUST, 1940

A meeting was held in the Society's Room on this date. Mr. W. H. Clemes presided in the absence of the President.

Miss J. Munro Ford was elected a member of the Society.

Mr. Leonard Cerutti delivered a lecture on 'Francis Bacon', of which the following is an abstract:—

Mr. Cerutti suggested that it might be profitable for members to study the works of Francis Bacon. There is a distrust of science exhibited in some quarters to-day, and free scientific thought is being attacked in the interests of state policies in Europe, so that contemplation of the doctrines of this man, who 'rang the bell which called the wits together', is salutary. 'His philosophical works have moved the intellects that have moved the world.'

The literary works of Francis Bacon display his unemotional mind, the poverty of his moral feelings, and his lack of warm human affection, but these defects scarcely detract from his contributions to scientific philosophy. He stood at the beginning of the modern scientific era, and in his two great works, *The Advancement of Learning* and the *Novum Organum*, he crystallized advanced thought of his time and established a basis for the work of the natural philosophers of the 17th century. He preached the doctrine of hard work in science; he insisted upon the danger of authority to scientific truth; and he emphasized the essential nobility of scientific investigation.

9TH SEPTEMBER, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presiding.

The following were elected members of the Society:—Professor J. B. Cleland, Mr. E. F. Fricke.

Mr. A. M. Olsen gave a paper entitled 'New Tasmanian Orchids'.

Mr. Olsen dealt with *Chiloglottis Pescottiana*, Rogers (Alpine Bird Orchid)—a slender glabrous plant about 8-18 cm. high. Leaves basal 2, oblong-lanceolate on long petioles. Flower solitary, greenish-bronze or wholly dark-prune. Lateral sepals linear-lanceolate, recurved, connate at base. Dorsal sepal spatulate-acuminate, about same length as lateral sepals. Petals lanceolate, wider than sepals but about same length. Labellum oblong, shorter than sepals, slightly recurved about the middle of lamina. Calli dark-purplish. One large crescentic sessile callus in middle line in advance of all others; a large bi-lobed stalked callus about midway between this and lamina base; and various small stalked calli around. Column winged above; another blunt; stigma circular.

This species is easily distinguished from all other known forms by the oblong canoe-shaped labellum.

It is known in Victoria only from Cravensville, Tallangatta Valley, N.E. Victoria, where it was discovered by Mr. A. B. Braine, the local school-master. It is fairly numerous in this locality. Found in Tasmania at Mt. Barrow, where also it is reported as abundant. The Collector is Mrs. Pearl Messmer, of Lindfield, Sydney, N.S.W.

Flowering period: September to November.

Mr. A. L. Meston gave an illustrated lecture on 'The Culture of the Tasmanians', of which the following is an abstract:—

The first group of slides dealt with the stone implements deliberately shaped for special service as tools. Many of these show skilful workmanship and reveal that the Tasmanians had made considerable advance in the technique of stone tool production. The lecturer attempted a classification of the implements, based on a very large number of specimens. The most abundant specialized form is the scraper with a snout, a tool which bears a marked resemblance to the *grattoir à museau* found in the upper levels of the Western European culture known as Aurignacian. Another abundant specialized implement is the point. Many of the specimens shown on the slides had delicate narrow secondary flaking, the work of skilled craftsmen. Concave scrapers, no doubt used as spoke shaves for smoothing the wooden spears and waddies, form another abundant group. Side scrapers, in which the cutting edge formed along the side of the flake is slightly convex, are well adapted as skinning tools. Other forms shown were high-backed or keeled scrapers, a highly specialized form of core scraper, and end scrapers. Several slides showed combination implements, and the characteristic oblique-angled striking platform of the Tasmanian lithic culture.

Besides these flake tools the lecturer showed the highly interesting and exceedingly primitive pebble choppers, known to science as the Sumatra type. Similar core implements may be collected in great numbers along the whole length of the east and south-east coast of Australia.

The third group of slides illustrated the bone implements used by the Tasmanians. These were of two distinct kinds, points and spatulas. Some have apparently been used as flaking tools, others for basket-weaving, though once again the use of these tools, unfortunately, is mainly conjectural.

An interesting slide was that depicting a basket made by Truganini, the last of the Tasmanians, for Miss Dandridge, and now in the lecturer's possession. Attention was drawn to the primitive basket weave.

Other slides dealt with the stone carvings of the Tasmanians at Devonport, Mt. Cameron West, and Trial Harbour; the small carefully shaped circular stone discs of unknown use, so frequent on West Coast middens; mill-stone, with well worked peripheral edges covered with red ochre pounded to form a raddle for the hair; hammer-stones of various shapes and sizes; and hut sites on the West Coast.

The lecturer also showed a unique skull drinking-cup, found on a midden close to a spring of sweet water at Port Sorell on the North West Coast. This is formed of a human skull top, which has been carefully cut into a drinking bowl, and has much similarity with the two skull ceremonial or drinking bowls from the Magdalenian layer in the great grotto of Placard in France.

7TH OCTOBER, 1940

A meeting was held in the Society's Room on this date. The President, His Excellency the Governor, presiding.

Mr. Gregory Mathews, C.B.E., F.R.S.E., M.B.O.U., &c., author of the Monograph on the Birds of Australia, lectured before the Society and dealt with the preliminary work involved in obtaining material upon which his twelve volumes of the Birds of Australia were based. In the first place he organized observers and collectors throughout the Commonwealth, having at one time as many as twelve expeditions simultaneously in the field. Upwards of 120,000 birds' skins were obtained. These had to be carefully examined for purposes of identification, and all the information regarding them had to be tabulated. At the same time that this work was proceeding he began a quest for historical works bearing upon Australian birds, and as a result of this many works of great value were discovered. The lecturer went on to speak of bird migration. A great deal still remains to be done regarding Australian bird migration, and it was important that migration routes should be determined as soon as possible.

In his introductory remarks the President referred appreciatively to Mr. Mathews' generous action in presenting to the Commonwealth Government his entire library dealing with Australian birds.

11TH NOVEMBER, 1940

A meeting was held in the Society's Room on this date. Mr. E. E. Unwin presided in the absence of the President.

Mr. D. Daish was elected a member of the Society.

The following papers were laid on the table and taken as read:—

(a) Consett Davis: 'Ecology of the S.W. Tasmania'.

(b) J. W. Evans: 'The Morphology of *Tettigarcta tomentosa* White (*Homoptera, Cicadidae*)'.

- (c) R. F. Cane: 'Studies in Tasmanite Shale Oil'.
- (d) P. B. Nye: 'Tertiary Marine Rocks of Far N.W. Districts of Tasmania'.
- (e) F. M. Carpenter: 'A New Genus of Mecoptera from Tasmania'.
- (f) A. B. Edwards: 'On a Remnant of a Stripped Peneplain of Palaeozoic Age at Mt. Sedgwick in Western Tasmania'.
- (g) E. O. G. Scott: 'Observations on Fishes of the Family Galaxiidae. Part III.'
- (h) W. H. Nicholls and A. M. Olsen: 'Additions and Corrections to the *Orchidaceae* of Tasmania'.
- (i) J. Pearson: 'The Heart and Great Vessels in the Marsupialia'.
- (j) J. Pearson: 'The Reproductive System in the Marsupialia'.

Mr. H. T. Parker delivered a lecture entitled 'Can Animals Think?', of which the following is an abstract:—

We are inclined to assess an animal's capacity for thinking by the aptness or the complexity of its behaviour. But in all animals behaviour is to a great extent innately determined, and does not call for thinking at all. Even actions which are learned do not of necessity originate in deliberation; they may be no more than modifications brought about by particular elements in the environment.

The question cannot well be discussed without some idea of what thinking implies. Even in its most elementary forms, thinking goes beyond immediate experience to a realization of meaning. When thought governs action, it does so by ideal construction, that is, by living through in imagination an experience which may later be lived through in fact. This is planning or forethought. One may not admit evidence for thinking in animals unless this element of forethought is present.

The cases of 'Clever Hans' and the Elberfeld horses are instances of learned reactions to barely perceptible signals, and do not involve thinking at all. The homing powers of dogs or other animals are instinctive and not rational. The hoarding tendencies exhibited in many animals, from squirrels to ants, if ascribed to thinking, could only be called stupid. It is only when we come to higher animals—dogs, cats, rats, racoons—that there is any evidence of true thought. This is most marked in the case of chimpanzees, as Kohler's experiments disclose.

The main instrument of human thought is language. The fact that no animals possess language except the elementary language of emotion restricts their thinking to a very rudimentary type.

Northern Branch

Annual Report, 1940

Meetings of the 1940 Session, other than the Annual Meeting and Public Lecture and the July Meeting (Demonstration at Commonwealth Health Laboratory), were held in the Lecture Room at the Queen Victoria Museum and Art Gallery. The extended programme of meetings initiated last year was maintained.

20TH MAY, 1940

Annual Report and Public Lecture

The Annual Meeting for 1940 was held in the class-room, Public Library, at 7.30 p.m.

Mr. F. Smithies presided. The following were elected officers for 1940:—

President: Mr. F. Smithies.

Council: Mr. F. Smithies (Chairman), Mr. F. Heyward, Hon. Tasman Shields, Mr. W. R. Rolph, Mr. R. S. Padman, Mr. J. R. Forward, Mr. D. V. Allen, Mr. J. E. Heritage, Dr. R. A. Scott.

Hon. Secretary: Mr. E. O. G. Scott.

Hon. Auditor: Mr. R. S. Padman.

The Annual Report and the Statement of Accounts, which showed a credit balance of £29 17s. 1d., were read and adopted.

The Annual Meeting was followed, at 8 p.m., by a public lecture, 'Romance of Tasman's Peninsula' by Rev. Lewis E. Barnard. The lecture was given in the Public Library Hall.

Mr. Barnard first gave a general account of the history of Tasman's Peninsula. The natural advantages of the Peninsula as the site for a penal colony were pointed out, and consideration was given to the methods of guarding Eaglehawk Neck devised by Capt. O'Hara Booth.

While the story of Tasman's Peninsula is inevitably largely the story of the penal system in Tasmania from the date of the foundation of Port Arthur, the lecturer chose to dwell chiefly upon the romantic, rather than the sordid, aspect of the period of occupation. Features dealt with included the signalling system, defence of the Neck, Martin Cash and his two escapes from Port Arthur, the history of the Church, the convict railway, and Commandant's house.

All phases of the subject were abundantly illustrated by means of lantern slides, a large number of the pictures shown depicting scenes at the settlement during the period of occupation.

24TH JUNE, 1940

The President, Mr. F. Smithies, presided.

Mr. E. O. G. Scott gave an illustrated lecture on 'Recent Researches on Fishes'.

Mr. Scott first touched briefly on the increasing differentiation of knowledge with the advance through the ages of science, and drew attention to the degree of specialisation that now characterises even restricted fields in biology. Some reminiscences of prominent ichthyologists in various parts of the world met by the lecturer on a recent tour were given, and reference made to some of the more important and more interesting researches carried out by them.

The introductory talk was followed by the showing of a series of lantern slides to illustrate recent researches on such subjects as fish locomotion; mass psychology; round-about paths, and the teaching of food-routes to fish; the influence of pH on growth; Australian investigation on life-history of pelagic fishes; influence of physical and chemical factors of the environment; matroclinous inheritance in *Mollienisia*; and allied topics.

The lecture was followed by a discussion, in which Mr. Holmes, Mr. Fricke, Mr. Evershed and others participated.

15TH JULY, 1940

The President, Mr. F. Smithies, presided.

Instead of the usual lecture, the meeting for July took the form of a demonstration by Dr. R. Y. Mathew, Medical Officer in Charge Commonwealth Health Laboratory, of the work of that institution.

Dr. Mathew gave a general account of the work of the Laboratory and indicated something of the scope and nature of its routine work. He had prepared about a dozen exhibits designed to show, by means both of actual specimens and explanatory notes, some standard methods of diagnostic procedure in the case of such diseases as tuberculosis; diphtheria; typhoid, and allied fevers; pernicious anaemia; several venereal diseases; etc. Associated with these exhibits were others illustrating various aspects of the investigation of the state of the blood. At the conclusion of Dr. Mathew's introductory talk, occupying about three-quarters of an hour, members circulated freely throughout the Laboratory, and inspected at leisure the interesting exhibits prepared for their examination.

As an addendum to his general remarks, Dr. Mathew briefly described, and showed examples of, biological products prepared at the Commonwealth Serum Laboratories, Melbourne.

An interesting discussion, in which the President, Mr. A. E. Evershed, Major Smith, Mr. F. J. Heyward, and the Secretary participated, followed the conclusion of Dr. Mathew's address. After members had finished their examination of the exhibits, demonstrations were given of the use of various types of apparatus employed in the institution's work, and a general tour of the Laboratory was made under the guidance of the lecturer.

19TH AUGUST, 1940

The President, Mr. F. Smithies, presided.

Mr. J. D. Valentine gave a lecture on 'Flax'.

Mr. Valentine gave a general description of the Flax Plant, *Linum*, and spoke of its importance as a source of oil and fibre—world-crop covers 19,000,000 acres, of which more than two-thirds is grown for seed, from which is obtained linseed oil. Attention was drawn to the fact that a special variety of the common flax, *Linum usitatissimum*, is used for the fibre of commerce.

The speaker then traced the history of flax and of the production of linen from the earliest times, giving some account of the important part it played in various civilisations, such as the Egyptian, Phoenician, Roman, and Grecian. Special attention was paid to the story of the flax industry in England and Ireland.

After enumerating some of the uses in wartime (for manufacture of 'planes, canvas, cordage, etc.), he spoke of the shortage of raw material due to the cessation of exports from Russia (which produces more than four-fifth of the world's supply). An account was then given of the scheme, sponsored by the British Government, for the planting in Australia of 20,000 acres (Tasmania's share 1,300 acres), with 400 tons of seed from England.

Mr. Valentine then traced in detail the process of manufacture of linen to the weaving stage; and afterwards proceeded to discuss the agricultural side of the problem, with detailed observations on the conditions and methods of growth, time of planting, suitable soils, fertilizers, methods of harvesting, etc.

The lecture was followed by a discussion in which Mr. Rolph, Mr. Smithies, Mr. D. V. Allen, and Mr. Evershed took part.

16TH SEPTEMBER, 1940

The President, Mr. F. Smithies, presided.

Dr. A. N. Lewis, who was welcomed to the Northern Branch by the President, gave a lecture on 'Tasmanian Physiographical History'. Before dealing with the subject of his talk, Dr. Lewis expressed pleasure at being present as a representative of the Council of the parent Society, and spoke of the helpful effect of interchange of lecturers between Hobart and Launceston in maintaining and extending general reciprocity between the parent body and the Branch.

Dr. Lewis then gave an illustrated lecture on 'Tasmanian Physiographical History'.

Dr. Lewis introduced his subject by briefly considering the importance of the environment to the individual and community. With the aid of an extensive series of lantern slides, depicting geologically interesting localities in all parts of the State, he gave an account of general physiographical principles, and pointed out the chief factors concerned in shaping the configuration of the landscape. Special attention was paid to the work of rivers, and the mode of action of this agency was dealt with in some detail. Consideration was also given to the effects of earth-movements in causing elevation and depression of the land; and to the various factors constantly at work in shaping the landscape.

After thus laying down some general principles, the speaker proceeded to trace in outline the story of the moulding of Tasmania. Points that received special attention included the formation of the present plateaux (now standing at a height of 3000-4000 feet), at, or near, sea-level; the comparatively recent elevation of these regions; the present stage of erosion; the partial rejuvenation of rivers such as the South Esk; the sharp line of demarcation between the older strata of the West Coast and the newer formations of the Midlands; the effects of pressure from the south-west; the history and nature of recent lava-flows; the order of deposition of various strata; the comparatively late intrusion of the diorite; varves on the West Coast; moraines; and the influence of ice-action generally.

Dr. Lewis having invited questions, there was an interesting discussion at the conclusion of the lecture.

21ST OCTOBER, 1940

The President, Mr. F. Smithies, presided.

Mr. H. J. King screened a series of Natural History Films, prepared in connexion with the educational programme of the Queen Victoria Museum, and gave a short address on 'Colour Photography'.

Mr. King briefly outlined the history and development of the production of camera-pictures in colour, and described the different principles adopted in the various commercial methods. The Kodachrome process, which was used in the present undertaking, was dealt with in some detail, and the various stages of processing the exposed film were explained. He concluded his address by reviewing the circumstances in which the films were made and by recalling some of the interesting incidents associated with their preparation. The Museum Natural History Films were then projected by Mr. King, who delivered a running commentary on them. An additional short film on Tasmanian Natural History was next screened, and was followed by one of Mr. King's own films depicting the Cradle Mountain Reserve.

At the conclusion of the meeting, supper was served in the Historical Art Gallery.

COUNCIL MEETINGS

Council Meetings were held on the 2nd May, 18th June, 18th July, 5th August, 2nd September, 4th October, 16th December.

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